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DIELECTRIC STRESSES

FROM THE MECHANICAL POINT OF VIEW.

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THE object of this paper is to discuss dielectric stresses from what may be called the mechanical as distinguished from the atomistic or electronic point of view. The discussion is based on two ideas, namely (*a*) That dielectric break-down occurs at a definite electric field intensity, and (*b*) That the line of dielectric break-down is a conducting path.

The present paper discusses dielectric stresses only insofar as they are modified by variations of inductivity and shapes of metal parts; fatigue effects (and other effects involving time), the peculiar break-down characteristics of very short air gaps, the corona discharge, and so on will be discussed in a second paper which will be based almost wholly upon the electron theory.

The ordinary practical units, ampere, ohm, volt, coulomb, farad, volt-centimetre, volt per centimetre, etc. are used exclusively in this paper.

A familiarity with the condenser is taken for granted. The equation of the condenser is:

$$Q = CE \qquad (1)$$

in which E is the electromotive force applied to the condenser plates, Q is the amount of charge drawn out of one plate and forced into the other plate, C is the capacity of the condenser.

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The capacity of a parallel plate condenser with air as the dielectric is

$$C = 884 \times 10^{-16} \frac{a}{x} \qquad (2)$$

in which a is the area of one of the plates (sectional area of the dielectric) in square centimetres, and x is the thickness of the dielectric in centimetres.

To substitute oil or any other dielectric for the air increases the capacity of a condenser in a certain ratio k so that the capacity may then be expressed by the equation

$$C_{farads} = 884 \times 10^{-16} \frac{ka}{x}. \qquad (3)$$

The factor k is called the *inductivity* of the dielectric (also sometimes called *specific capacity* of the dielectric). Thus the inductivity of kerosene is about 2, which means that the capacity of an air condenser is doubled if kerosene is substituted for the air dielectric.

In the following discussion the letter B is used to designate the factor 884×10^{-16}.

GAUSSES THEOREM.

A theorem of fundamental importance in electrostatic theory is as follows: The total electric flux ϕ emanating from a charged body is equal to $Q \div B$, or the total charge on a body is equal to $B\phi$, where Q is the charge in coulombs and ϕ is electric flux expressed in volt-centimetres in air. (An electric field intensity is expressed in volts per centimetre, and the product of this field intensity by an area in square centimetres gives electric flux in volt-centimetres, the area being perpendicular to the field.)

When applied to a parallel-plate air condenser, Gausses theorem may be derived by multiplying both members of equation (2) by E (the electromotive force between the plates), giving:

$$CE = Q_{coulombs} = Ba\frac{E}{x}$$

but $E \div x$ is the electric field intensity between the plates in volts per centimetre, so that $a \times E \div x$ is the electric flux from

plate to plate in volt-centimetres and therefore, $a \times E \div x = \Phi$ whence we have

$$Q = B\phi \qquad (4)$$

Gausses theorem may be derived for a parallel plate condenser with any dielectric by multiplying both members of equation (3) by E (the electromotive force between the plates), giving:

$$CE = Q = B \cdot a \cdot k\frac{E}{x}$$

but $E \div x$ is, as before, the electric field intensity between the plates and $k \times E \div x$ may be defined as the *electric flux density* in the dielectric, so that $a \times kE \div x$ is the total flux, and we thus arrive again at equation (4).

MAGNETIC AND ELECTRIC PARALLEL.

$B = \mu H$

Where H is intensity of magnetic field in gausses, μ is the permeability of the medium, and B is the magnetic flux density.

$F = kf$

Where f is intensity of electric field in volts per centimetre ($E \div x$), k is the inductivity of the medium, and F is the electric flux density in volt-centimetres per square centimetre.

ELECTRICAL STRESS AND MECHANICAL STRESS.

The stretching force per unit of sectional area of a rod is called the *stress* on the rod, and the elongation of unit length of the rod is called the *strain;* and the strain is proportional to the stress. That is

strain=constant × stress.

This constant is the reciprocal of what is usually called the modulus of elasticity, and it is large in value for a substance like rubber which is greatly stretched by a moderate stress.

The intensity of an electric field in volts per centimetre (or the volts per centimetre in a layer of dielectric between metal plates) is frequently called *electrical stress,* and the electric flux density kf in the dielectric is frequently called the *electrical strain.* Therefore we have

electrical strain $= k \times$ *electrical stress.*

The inductivity of a dielectric is analogous to an elastic constant (reciprocal of what is called modulus of elasticity). The product kf, which we call electric flux density or electric strain, was called *dielectric polarization* by Maxwell.

In some cases electric flux density (or strain) is given instead of electrical field intensity (or stress) when it is desired to specify the condition of a dielectric. Now electric flux can be expressed in coulombs according to equation (4), B being a numerical factor. Therefore electric flux density (or strain) may be expressed in coulombs per unit area. Thus electric strain is sometimes expressed in coulombs per square inch.[1]

ELECTRIC STRESSES IN PLANE LAYERS OF DIFFERENT DIELECTRICS.

Consider two metal plates with equal thicknesses of air ($k = 1$) and of glass ($k = 6$) between them as shown in Fig. 1. The thing which is constant throughout the region between the metal plates, that is, the thing which has the same value in glass and air is electric flux density kf, because there are equal and opposite charges on two plates, and, therefore according to Gausses theorem the total flux passing out from the positively charged plate ($+Q$) is equal to the total flux passing in towards the negatively charged plate ($-Q$). Now since kf is the same in the glass and in the air, and since $k = 1$ for air and $k = 6$ for glass, therefore electric field intensity or stress in volts per centimetre (f) is six times as great in the air as in the glass.

Consider the special case in which the glass and air are of equal thickness as indicated in Fig. 1. Then six-sevenths of the battery voltage is impressed on the air layer and one-seventh on the glass layer. If glass and air are each 1 centimetre thick, and if the total voltage is 35,000 volts, then, assuming the air not to break down, the voltage across the air will be 30,000 volts, and the voltage across the glass will be 5000 volts.

If the glass plate is removed, leaving 2 centemetres of air, then the electrical stress on the air will be 17,500 volts per centimetre. Therefore the electrical stress in the air between two plates 2 centimetres apart is increased from 17,500 volts per centimetre to 30,000 volts per centimetre by filling half of the space between the plates with glass of inductivity 6.

[1] In a recent paper before the American Institute of Electrical engineers an author states that this method of specifying electrical strain is so little understood that he deems it justifyable to give a full discussion of the matter, and he arrives by a confused argument to the wrong result "coulombs per inch cube."

This effect can be shown in a very beautiful manner by connecting two metal plates to a high-voltage transformer and adjusting the plates to a distance such that the intervening air layer is barely sufficient to sustain the voltage. Then if a glass plate be introduced between the metal plates, the electrical stress in the remaining air will be increased sufficiently to break the air down at each reversal of the alternating voltage, as shown by the bluish luminosity of the air layer.

The above discussion of the stresses in layers of glass and air as based on Fig. 1 can be simplified as follows: Imagine a thin sheet of metal *m m* to be placed between the air and glass as shown in Fig. 2. We thus have two exactly similar condensers, *C'* and *C*, of glass and air, and the capacity of the glass

FIG. 1.

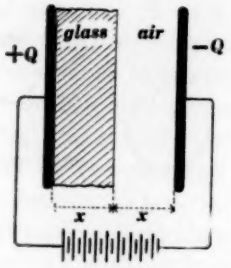
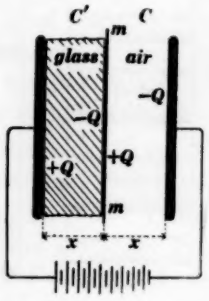


FIG. 2.



condenser is six times as great as the capacity of the air condenser, according to equations (2) and (3). But the charges on *C'* and *C* are the same because they have been charged in series. Therefore the voltage across the glass condenser is one-sixth of the voltage across the air condenser, according to equation (1).

The concentration of the greater part of the voltage upon the air layer in Figs. 1 and 2 is exactly analogous to the concentration of the greater part of the magnetomotive force of a dynamo field-winding upon the air gap in the magnetic circuit; only a small portion of the magnetomotive force is required to force the magnetic flux through the highly permeable iron, and a large portion of the magnetomotive force is required to force

the magnetic flux through the less permeable air layer. A small portion of the battery voltage is required to force the electric flux through the highly inductive glass in Fig. 1 and a large portion of the voltage is required to force the electric flux through the less inductive air.

MECHANICAL ANALOG OF FIG 1.

A difficulty in obtaining a simple mechanical idea of the concontration of the greater part of the battery voltage on the air layer in Fig. 1 arises from the following fact: the glass and the air are *in series* in Fig. 1 (and the electric flux density or *electric strain* or yield, in the two is the same), whereas two mechanical elements have the same *stress* when they are in

FIG. 3.

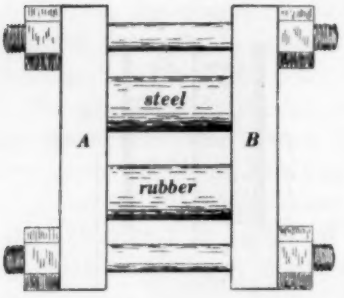
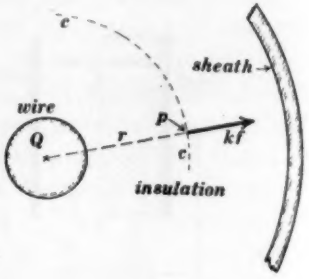


FIG. 4.



series; to have the same strain or yield, two mechanical elements must be *in parallel.* Thus Fig. 3 shows a column of steel and a column of rubber equally compressed between two bars *A* and *B* (the steel and rubber columns are in parallel); the easily yielding rubber (high inductivity) supports a small part of the compressing force, and the stiff steel (low inductivity) supports a large part of the compressing force.

THE GRADED CABLE INSULATION.

Influence of Variation of Inductivity on Electrical Stress.—Consider unit length of the wire core of a cable and let Q be the amount of electric charge thereon. Let f be the electric field intensity in volts per centimetre at the point p in the insulation

distant r from the axis of the cable and let k be the inductivity of the insulating material at p. Then kf (see Fig. 4) is the electric flux density at p, and $2\pi r \times kf$ is the flux across the cylindrical surface cc (of unit length), that is $2\pi rkf$ is the flux emanating from Q, and, therefore, according, to equation (4), we have

$$Q = B \times 2\pi rkf$$

or

$$f = \frac{1}{2\pi B} \cdot \frac{Q}{rk}. \qquad (5)$$

Therefore, if k decreases as r increases so that the product rk is constant, then the electrical stress f, in volts per centimetre, will be the same in value throughout the cable insulation.

There is an interesting mechanical analogy to the graded cable insulation. If a thick walled steel tube is subjected to internal pressure as in a cannon, the material next the bore is stretched to its stress-limit before the outer portions of the steel are brought into full action. If easily yielding (high elastic like rubber) steel could be used for the inner portions of the gun tube, then the greater yield of the inner material would tend to bring all of the material of the tube up to the limiting stress simultaneously. There is in fact but little variation in the elastic coefficient of various kinds of steel, and this method of gun construction in therefore impracticable. There are, however, great differences in the inductivities of different insulating materials, and therefore the grading of cable insulation is to some extent practicable.

EXPERIMENTAL EFFECTS DEPENDENT UPON INDUCTIVITY.

The lines of force in an electric field converge upon and pass through a glass rod (high inductivity), and the lines of force in a magnetic field converge upon and pass through an iron rod (high permeability). A glass rod suspended in an electric field oscillates to and fro through an equilibrium position parallel to the field in the same way that a suspended iron rod oscillates in a magnetic field. (Figs. 5 and 6.)

A glass plate is drawn into the intense electric field between

positively charged metal plates in the same way that a piece of iron is drawn into the intense magnetic field between two opposite magnet poles as shown in Figs. 7 and 8. In the same way oil and especially water is drawn into the most intense part of an electric field.

A thin glass cell partly filled with oil and provided with metal terminals *A* and *B* is placed in a lantern and the terminals *A* and *B* are connected to a Toepler-Holtz machine, as indicated

FIG. 5.

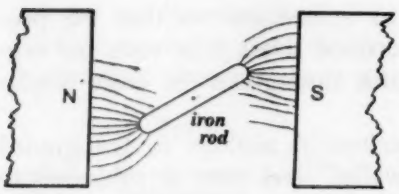


FIG. 6.

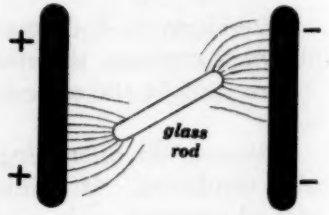


FIG. 7.

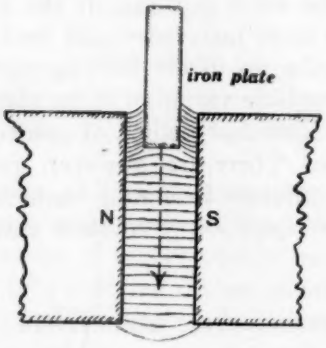
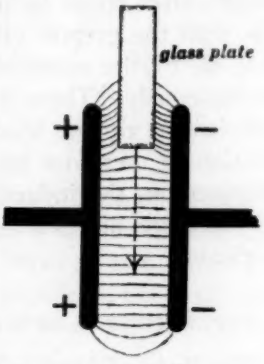


FIG. 8.



in Fig. 9. The oil (high inductivity) is drawn up as shown, and eventually a column of oil is formed reaching up to terminal *A*. In the same way a magnetic liquid (permeability greater than unity) would be drawn up to a magnet pole.

Bubbles of air rising in oil in front of a blunt metal terminal (charged) are repelled.

A gold-leaf electoscope is placed in a lantern, and the plate of the electroscope is connected by a fine wire to an insulated plate *PP* on the lecture table, as shown in Fig. 10. When a slab of paraffin wax *W* is placed in the region *CC*, the electroscope leaves fall slightly. The capacity of the condenser *CC* has been increased by the paraffin slab and a greater portion of the charge on the insulated system flows into *PP* thus decreasing the charge on the electroscope leaves. If one had two inflated rubber bags connected by a tube, and if one were to make the walls of one bag more yielding by dissolving off a portion of the rubber (if that were possible), then the weakened

FIG. 9.

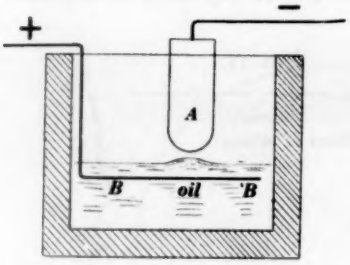
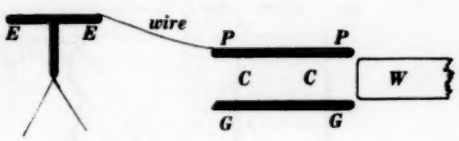


FIG. 10.



bag would swell and the other bag would shrink. The plate of paraffin makes the dielectric around *PP* more yielding and some charge flows from *EE* into *PP*.

DIELECTRIC HYSTERESIS.

The most prominent kind of dielectric hysteresis is a kind which is closely analogous to what is technically called ***elastic lag*** in mechanics. Glass, for example, when subjected to a mechanical stress takes on a certain amount of strain (deformation) quickly, after which the strain slowly increases for a time; and when the stress is removed, a remnant of the strain persists for a time. This kind of hysteresis is sometimes called ***viscous hysteresis,*** and it is very different from the magnetic hysteresis in iron or steel, although a slight amount of viscous hysteresis does exist in very soft iron.

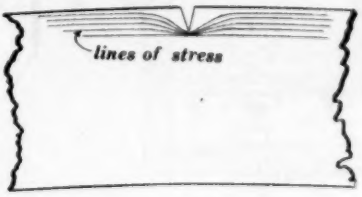
Dielectric hysteresis of the viscous type has long been known to exist, and it is the cause of the so-called "residual charge" which accumulates in a Leyden jar when the jar is completely discharged and allowed to stand.

A Leyden jar is charged. The coatings of the jar are then momentarily connected by wire, and then the jar is left standing on open circuit. After a time the coatings are again connected and a second slight discharge is obtained.

FIG. 11.

A rubber tube is stretched. This stretch corresponds to the electrical strain of the glass walls of the Leyden jar. The end of the tube is momentarily released, and the end is then clamped fast in what seems to be its equilibrium position. After a time the end is again released and a second slight "discharge" or movement takes place.

FIG. 12.



GLEITFUNKEN.

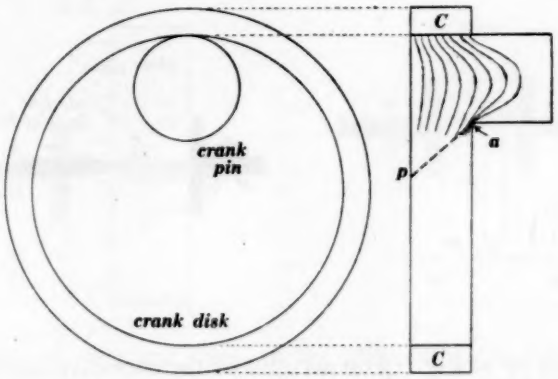
Everyone who has used Leyden jars is familiar with the fact that a spark will often jump seven or eight inches over the edge of a jar from tin-foil to tin-foil, when the coatings are connected to a spark-gap of an inch or an inch and a half. A surface of contract of two dielectrics of different inductivities is electrically very weak even when it is free from dirt and dust. The explanation of this fact for the simple case of the Leyden jar is as follows: Consider the dotted line in Fig. 11 (a tube of electric flux) partly in air and partly in glass. The voltage between the tin-foil coatings is concentrated in the air portions of the tube of flux because of the high inductivity of the glass, and the air portions break down. Tubes of flux then pass between the charged fringes beyond the edges of the tin-foil, and the action is repeated, and so on, until a spark jumps over

the edge of the jar. A strip of window glass placed edgewise in the spark-gap of a Toepler-Holtz machine causes a spark to jump 1½ or 2 inches when a 1-inch spark-gap (without a glass strip) is connected in parallel with the spark-gap of the machine.

CONCENTRATION OF ELECTRICAL STRESSES BY POINTS.

The ease with which a bar of hard tool-steel can be broken when a sharp-bottomed nick is made in one side of the bar is well known. Fig. 12 shows the lines of stress passing around the bottom of a sharp groove in a bent bar. The stress is very greatly concentrated near the bottom of the groove, and the grooves deepens by the formation of a crack. The stress is then

FIG. 13.



concentrated at the edge of the crack, and the crack is extended farther and farther until the bar is broken in two.

It is perhaps not universally known that the glass-cutting diamond does not make a scratch. Such a scratch would be a shallow flat-bottomed groove, and no very great concentration of stress would occur at the bottom of such a groove when the pane of glass is slightly bent. The end of a cutting diamond is a perfectly rounded "corner" of a natural diamond crystal (the diamond is a crystal with curved faces), and when a cutting diamond is drawn properly across a pane of glass a minute crack is formed under the diamond on account of the excessive

local compression. This crack causes a very great concentration of stress when the pane of glass is subjected to a very slight bending action, and the result is that the crack runs through the pane. When a diamond is drawn heavily across a pane of glass a very considerable exertion is required to break the glass and the crack does not always follow the groove. When a diamond is drawn properly across a pane of glass a very slight bending movement is required to break the glass, and the break nearly always follows the minute crack produced by the diamond.

A very interesting accident occurred at the Bethlehem Steel Works a number of years ago when an attempt was made to strengthen a crank-disk by shrinking a collar upon it. The disk had a crank-pin on one side, and the disk sheared off along the

FIG. 14.

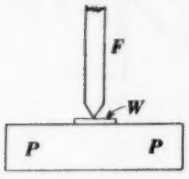
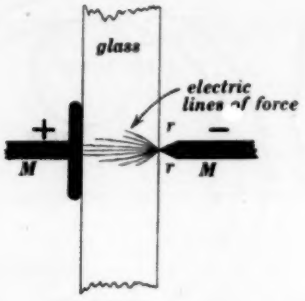


FIG. 15.



dotted line *ap* in Fig. 13 on account of the excessive concentration of stress at the reëntrant angle *a*. The fine curved lines show the approximate trend of the stress lines in the disk due to the collar *CC*.

An interesting experiment is to place a small piece of window glass on a flat plate of steel (or plate glass) and press a sharp-pointed file against it as shown in Fig 14. The stresses in the window glass are very greatly concentrated at the sharp point of the file, and it takes but little force on the file to break the glass to pieces. If, however, a bit of soft copper is placed under the point of the file, one cannot push hard enough to break the glass; the copper yields (breaks down mechanically) and distributes the stress.

When a voltage is applied to the metal terminals *MM* in Fig. 15, the electric lines of force (the electrical stress lines) converge upon the sharp metal point and the electrical stress is very greatly concentrated near the point. Indeed a comparatively low voltage will rupture the glass plate in Fig. 15 because of the starting of an electric rupture by the excessive concentration of the stress near the metal point. To produce this result, however, the region *rr* must be filled with a substance of great dielectric strength like turpentine or wax. If the region *rr* is filled with a substance of low dielectric strength like air, the portion in the immediate neighborhood of the metal point breaks down electrically and becomes a conductor, and the resultant

FIG. 16.

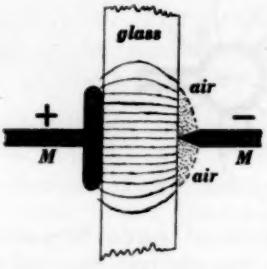
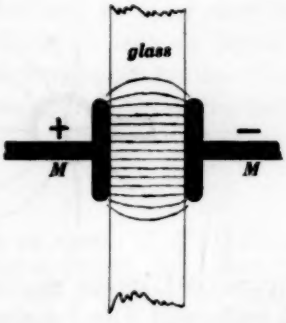


FIG. 17.



distibution of electrical stress in the glass plate (which is shown in Fig. 16) is the same as if the glass plate were between two flat metal plates as shown in Fig. 17. Under these conditions the electrical stress in the glass is nearly uniform, and a very high voltage is required to puncture the glass plate because there is no region of concentrated stress to start the electrical breakdown.

Having air around the metal point in Fig. 15 is like having a bed of soft copper around the point of the file in Fig. 14. The copper breaks down mechanically and distributes the stress, thus preventing excessive concentration of stress near the point of the file and the starting of a crack thereby. The air breaks down electrically and distributes the stress, thus preventing ex-

cessive concentration of stress near the metal point and the starting of an electric puncture thereby.

An electrical breakdown in a solid dielectric (and usually in liquid and gaseous dielectrics also) is always in the form of a puncture, that is the breakdown occurs along a line; and this line of breakdown is an electrical conductor. Therefore the electrical stresses in the dielectric are concentrated at the end of an incipient puncture, as at a metal point, and the puncture is thus carried through the dielectric or into regions where the electrical stresses were far below the breakdown value before the puncture started. These details were first definitely studied by Jean [2] in 1858; in describing his results, however, Jean does not of course use the language of mechanical analogy which is here employed.

FIG. 18.

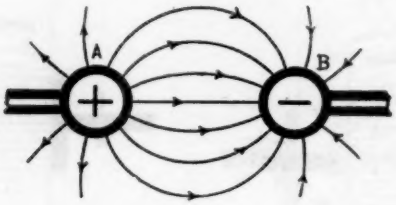


Figure 18 [3] shows the electric lines of force between two metal balls, and Fig. 19 shows how the electric lines of force rearrange themselves when an electric puncture starts.

The voltage required to puncture a homogeneous layer of dielectric is very nearly proportional to the thickness of the layer when the electrodes are flat metal plates as shown in Fig. 17; but the concentration of stress near metal balls as shown in Fig. 18 and near a metal point as shown in Fig. 15 introduces a complication, the sparking voltage is far from being proportional to the thickness of the dielectric between balls or points.

Many dielectrics are very heterogeneous, containing moisture in the interior, for example, and the voltage required to rupture

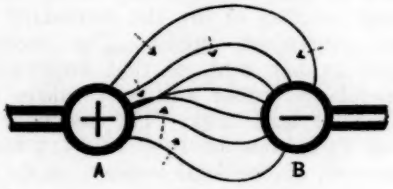
[2] Compt. rend., xlvi, 186, 1858.

[3] Figures 18 and 19 are taken from Nichols and Franklin's "Elements of Physics," vol. ii (Electricity and Magnetism). The Macmillan Company, 1896.

such a dielectric between flat plates is far from being proportional to the thickness.

For very small sparking distances in air at normal atmospheric pressure the breakdown stress in volts per centimetre becomes very great. That is, the proportional relation between

FIG. 19.



voltage and sparking distance does not hold for very short spark gaps in air and perhaps the same thing is true of liquid and solid dielectrics. The peculiar breakdown characteristics of short air gaps will be considered in a second paper in which the electron theory will be prominently used.

Production of Secondary Metals in 1909. J. P. DUNLOP.—The United States Geological Survey's figures of recovery of "secondary" copper, lead, zinc, tin, and antimony in 1909 are summarized below in the accompanying table. The secondary metals include those recovered from scrap metal, sweepings, drosses, etc. They are called "secondary" to distinguish them from the metals derived from ore, which are known as "primary" metals.

The following table gives the quantity and value of each secondary metal recovered during the years 1907, 1908, and 1909. The large increase shown in 1909 was occasioned partly by increased business activity and the growing tendency toward conservation, but is explained in part by the fact that the Survey made a more extensive canvass of the sources of production. Many manufacturers who formerly sold their scrap metal, sweepings, skimmings, and drosses now treat them in their own plants. The economic importance of the recovery and use of metal products from scrap metal, etc., is best emphasized by the figures given in the table, and if approximate data could be presented giving the value of the precious metals and of the large quantities of old iron and steel reused the immense value of secondary metals would be even more impressive. As these secondary metals displace equal quantities of primary metal in supplying consumption, they un-

doubtedly affect the prices of primary metals to some extent now and will affect them even more in the future.

The production of secondary copper (including that in brass) was equal to 6.4 per cent. of the total quantity of copper derived from ore in 1909. The secondary lead equalled more than 9 per cent. of the refined lead produced in the United States in 1909. The secondary zinc (including that in brass) equalled 16.5 per cent. of the total production of primary spelter. As there was no reported production in 1909 of antimony from domestic ores and only an insignificant quantity of tin, the secondary recoveries were the only domestic source of supply. The secondary antimony reported was about 25 per cent. of that imported as metal, exclusive of type metal and other antimony alloys or contained in antimony or antimonial lead ores. The secondary tin recovered has increased from 1562 tons in 1907 to 5515 tons in 1909 and now equals 11 per cent. of the total imports of tin into the United States.

Nearly all the establishments making secondary recoveries are in Eastern and Northern States, for it is not the old-junk man who supplies the larger quantity of old and waste metal but the larger manufacturing plants and railways.

PRODUCTION OF SECONDARY METALS IN THE UNITED STATES IN 1907–1909.

Metals.	1907		1908		1909	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Secondary copper, including that in alloys other than brass	30,240	$11,188,800	11,500	$3,036,000	25,396	$6,602,960
Remelted brass	(a)	.....	(a)	.....	27,347	5,863,181
Secondary lead	9,990	2,702,788	7,990	1,556,772	17,822	3,538,814
Recovered lead in alloys	15,508		10,543		23,327	
Secondary spelter	18,841	2,390,444	16,970	1,657,690	33,040	3,695,868
Recovered zinc in alloys other than brass	1,417		665		1,181	
Secondary tin	93	914,404	1,124	1,641,476	2,423	3,281,425
Recovered tin in alloys	1,569		1,666		3,092	
Secondary antimony	(a)	.....	(a)	.....	27	257,362
Recovered antimony in alloys	.....	.....	.....	.....	1,529	
Total value	.....	17,196,436	.....	7,891,938	.....	23,239,610

[a] Statistics not collected.

The Physical Meaning of Entropy. A. L. MENZIN. (*Eng. News*, lxiv, 229.)—The general definition is: In the conversion of heat into work, whether of heat external to a working substance, or contained within it as intrinsic energy, entropy is the minimum unavoidable waste per degree of the absolute temperature at which all of this waste may be rejected by the working substance.

WATER FILTRATION FOR INDUSTRIAL PURPOSES.

BY

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Filtration Engineer.

(*Presented at the Stated Meeting held Wednesday, January 18, 1911.*)

IT is frequently a matter of surprise to otherwise well informed persons that the ordinary standards of purity required in drinking water are sometimes not nearly as severe as those required in water used for industrial purposes. Nevertheless, this is true in many instances, because the water contains certain substances which are perfectly harmless to the human system but possess chemical affinities for other substances used in the arts and industries that create very annoying disturbances indeed. On the other hand, many waters that have been so highly contaminated by sewage and industrial wastes that no form of purification would make them suitable for drinking purposes, can be made eminently satisfactory for industrial purposes. It is a by no means uncommon condition to find a manufactory unable to use the city supply, which may be justly considered especially fine from a potable stand-point, yet by means of an efficient purification plant be able to get perfect satisfaction from a polluted stream which receives the sewage and industrial waste of the town itself.

Disregarding the hardness of the water, the reduction of which is not properly a function of filtration, there are a number of apparently harmless forms of pollution that are very troublesome in many instances.

The writer has in mind a rather remarkable case in a New York village of a manufactory wherein very gorgeously printed lap robes are made. This concern has been in business a great many years and the designs, which are quite ornate and many colored, are hand printed by large wooden blocks with certain colors imported from England supposed to be secret mixtures. These colors are all mordanted with alum. In fact, the robes themselves are passed through quite a strong solution of alum at one period of their manufacture, and are then dried. They are

finally washed, and at this point the trouble manifests itself in a rather singular manner. As soon as the water commences to get warm, or during the latter part of May, the light colors commence to get flat and as the season progresses and hot weather comes on, much of the detail is altogether lost and the whites and light shades commence to assume a yellowish cast. The wise men of the block printers shake their heads and say their secret colors are effected by the warm water and as a result robes of a dark shade only can be made during the warm weather.

An investigation of the water supply elicited the information that the major part of it is derived from a shallow lake about seven miles back in the country. The elevation of the water in this lake had been raised four or five feet a number of years ago and overflows a peat-bog over a square mile in extent. During the winter it is customary to close the outlet of this lake and allow it to fill up. About the latter part of May, when the water in the stream begins to get low the gates are opened and the highly colored water from the lake takes the place of the comparatively clear flow. When this colored water reaches the mill and the alum saturated lap robes are washed in it, the coloring matter derived from the peat is precipitated by the alum upon the fibre, and the more color there is to the water the greater the discoloration of the goods. Moreover, the drainage area of the lake being comparatively small and the drain upon the lake heavy the water keeps getting lower and lower until part of the peat-bog is exposed and the water percolating from this causes the lake supply to grow continually darker until the fall rains refill the lake. It can be seen by this that the color of the water and not the temperature is entirely responsible for the apparently bad behavior of the dyes. The above is a harmless but not too attractive city supply.

Another instance is in a city of some 60,000 inhabitants supplied from a fairly large stream. The water from this stream possesses considerable color and is filtered by means of a mechanical filter plant. This mechanical filter plant is very well operated indeed, shows a very high bacterial efficiency and is ideal in every particular save one, and that is that for some reason or other a small amount of hydrate of alumina, formed

during the chemical treatment of the water with alum, finds its way through the filters. This has no hygienic significance whatever and the inhabitants of the town are enthusiastic over the many virtues of their filter plant insofar as the potability and appearance of the water is concerned. However, there are a number of large silk dye-works in this town and this trace of hydrate of alumina present in the water prohibits its use in silk dyeing. Most of the dye houses are located along the banks of the same stream from which the city supply is drawn but at a point below town. The stream at this point is not only badly contaminated with sewage but the discharge from the silk dye houses themselves enters into it making the general color of the water blue-black. Nevertheless, the silk dyers have solved the problem of water supply by filtering this badly contaminated water with a filter which will not permit hydrate of alumina to pass through it. The filtered water is, of course, crystal clear and entirely free from dye.

Still again the anæmic person who spends some weeks at a high-priced sanitarium drinking chalybeate waters with the hope of bringing the iron content of his system up to the normal 26 or 27 grammes which it should contain would probably be quite indignant if told that the water he is drinking in such quantities is not even fit for laundry purposes.

Originally filtration for industrial purposes meant the removal of clay, silt, and vegetable stains from the water. The problem at that time was a simple one as it merely meant that enough alum or sulphate of alumina or similar coagulant was employed as a preliminary treatment, after which the water could be passed through the filters and would be suitable for industrial purposes.

However, as the country became more populated, its manufactories larger and more numerous, the streams commenced to show considerable quantities of various forms of industrial wastes and sewage. The industrial wastes consisted very largely of dyestuffs, waste liquors from paper and pulp mills, chemical wastes from wire-drawing plants, gas-house liquors, tannery wastes, etc. Some streams contained only one or two different varieties of contamination while others contained several. This condition has increased with the population until most of the

streams in the East are greatly discolored and are badly polluted with sewage. Moreover, most of the available sources of pure water have been preëmpted by municipalities for their water supplies.

Cheap water is imperative in the present day to the manufacturer. He cannot afford to pay from four to thirty-five cents per thousand gallons to the municipality for several million gallons of water per day and he is perforce driven to the polluted streams, his only alternative being to place his establishment at so remote a point that it becomes difficult of access and almost impossible to procure labor. Naturally he chooses the situation of his plant with reference to the availability of labor and the propinquity of the market. The vital question that then comes before him is, can the highly polluted water supply which is available be made suitable for his purposes? The answer to this question, in ninety-nine cases out of one hundred, is in the affirmative. It can be done and done well. Moreover, in large plants the average cost of treatment can be kept well below $3.50 per million gallons, or say one-third of one cent per thousand gallons as against the four to thirty-five cents per thousand the manufacturer would be compelled to pay to the municipality.

Such conditions as the last represent perhaps seventy-five per cent. of the problems of industrial filtration at the present day and the percentage is continually increasing.

The problems involved in such waters, especially when contaminated by many different substances, become complex in their nature. True, the old stand-by sulphate of alumina, still figures very extensively in all such plants, but there are many conditions wherein the use of sulphate of alumina alone as a preliminary treatment leads to a downright failure of the filter plant to accomplish the desired aims. To reach perfect results an intimate knowledge of the nature of the contamination must be reached. Chemical analysis, of course, tells us much and a bacteriological analysis is also necessary in some cases but an actual survey of the conditions to be met must be made before an intelligent purification plant can be constructed.

In making this survey it is necessary, particularly on a comparatively small stream, to notice the particular hours at which

certain industries discharge the most waste; to note the particular character of the most important of these wastes and to further note very particularly the influence that one set of industrial wastes will have upon another. For instance, the waste dye from a woolen mill mingling with the waste soap from the fulling and finishing department eventually come into contact with the lime existing in the water with the result that not only the soap is precipitated but a very considerable portion of the coloring matter is also carried down. Further down stream we may strike the waste from a wire drawing works or similar industry wherein sulphate of iron enters the water. This combines very actively with the coloring matter and forms a heavy precipitation. At the same time large quantities of domestic sewage are being discharged into the stream. This commences to ferment very rapidly. Portions of it are liquified and other portions precipitated. Bacteria become very active in the stream unless some poisonous or antiseptic substance is being discharged in it. By the time the water has reached the consumer possibly as high as seventy-five per cent. of the dissolved matter that had been discharged into the stream is delivered in a precipitated form, thereby lessening the load on the purification plant by that amount.

Now after having considered all of these points we come to the operation of the plant itself. In the first place we wish to get rid of the already precipitated matter as economically and as efficiently as possible. In the next place we must precipitate as cheaply as possible the remaining deleterious substances. As above stated the most economical and effective substance for doing the major part of this work is sulphate of alumina. The writer realizes that there will be considerable protest made in favor of sulphate of iron and lime. Nevertheless so far as his own experience goes, and, in fact, the experience of some others, sulphate of alumina is cheaper, safer, more satisfactory and far easier to apply than sulphate of iron and lime.

Having applied the sulphate of alumina with a due regard for the alkalinity of the water as evinced by the chemical analysis, the treated water is allowed to flow slowly through a settling tank. The period of time occupied in sedimentation varies greatly with different waters. In some cases one and one-

half hours may be sufficient. In others three hours. Occasionally twelve hours are required, and we know of one instance in which six days' sedimentation is employed. In the latter instance chemicals are not used, the biological conversion of the organic matter being aimed at. Generally speaking, however, three hours' sedimentation wtih aluminum sulphate for a coagulant is sufficient.

We occasionally find, however, upon operating a plant that complete decoloration of the water is not effected and that there is a very offensive odor. Moreover, strange things are taking place in the settling basin. As we look at it we see large masses of sediment rise from the depths, come to the surface, spread out and disappear. One point in the sedimentation basin will show a fairly good degree of sedimentation while further along where sedimentation ought to be further advanced we find the water far more turbid than when first introduced into the basin. The sewage in the water is simply fermenting and this fermentation is not only interfering with sedimentation by reason of the gases evolved but is producing resolution of the impurities entrapped by the hydrate of alumina. In other words we are undoing the good work we have done. Moreover, the volume of impurities going to the filter is far greater than it should be and the filters are requiring altogether too frequent washing.

Shortly afterwards a very singular manifestation takes place. The filters, which have been delivering a gradually deteriorating effluent finally refuse to deliver any water at all. An examination of the sand after washing shows it to be perfectly clean and there is no apparent reason why the water should not pass through. Nevertheless the filters are nearly impervious. A more thorough examination develops the fact that the pipes in the underdrains of the filters have become completely filled with a fungus growth, usually beggiatoa or sewage fungus. We clean it out and in a few days the same condition occurs again, the water that does come through is unusable.

The above conditions might take place in a filter plant provided we were confined to sulphate of alumina. However, with a knowledge of troubles about to occur we can guard against them by taking the proper precautions. The Imhoff tank which has been recently so successful in the removal of sludge from sewage might be applicable in this case, but there is a consider-

able doubt in the writer's mind whether complete decolorization of the water could be effected by filtration after the water had passed through such an apparatus without a subsequent chemical treatment. It is necessary to stop the fermentation of the precipitated matter. We can often do this by the addition of copper sulphate in fairly large proportions, say for instance, two or three parts to the million. This in certain cases is sufficient. The fermentation stops, sedimentation is good, the growths in the pipes gradually disappear, the effluent of the filter becomes clear, sparkling and odorless and everything is satisfactory. However, there are many cases where copper sulphate cannot be used in sufficient quantities, or where it is not useful at all. Where the percentage of sewage is very high we find that there is much undecomposed and unprecipitated organic matter in the water and to get really satisfactory results it must be consumed in some manner. Some powerful oxidizing agent is required. In such instances calcium hypochlorite recommends itself. This is to be used very judiciously as a very faint excess indeed would produce the most disastrous results in dyeing, but when accurately applied it consumes the dissolved organic matter as thoroughly and as effectually as if it were dried and burned in a fire. Moreover, it is a tremendously powerful bacteriacide and a bacterial analysis of the treated water shows it to be almost sterile even before filtration.

At Passaic, N. J., using Passaic River water, which runs about one million bacteria per cubic centimetre, or equal to ordinary sewage, it was found that with two parts per million of calcium hypochlorite and five hours' sedimentation the bacteria ranged from twenty-seven to one hundred per cubic centimetre, and that so long as the hypochlorite was used there was no tendency whatever of the sludge at the bottom of the basin to ferment.

In most plants the amount of calcium hypochlorite employed ranges from one to three parts per million. Where fermentation is interfering with sedimentation it must be applied as the water enters the sedimentation basin but if sedimentation is reasonably good an economy can be effected by applying the calcium hypochlorite after sedimentation is completed. By following this procedure much of the oxidizable matter that would be precipitated by the alum has settled to the bottom and the

principal oxidizing activity of the hypochlorite is directed against the dissolved matter and the bacteria.

Another action of the calcium hypochlorite is to decolorize the dyes that may have resisted action of the aluminum sulphate. This action, however, is not especially important as the strength required to produce this result is usually greater than is safe to use.

Needless to say the treated water must show no trace whatever of free calcium hypochlorite and the only logical way of attaining this result is to keep the quantity of chemical applied at such a point that its energy will be entirely expended upon the organic matter. An accurate chemical feed is of the utmost importance when using the calcium hypochlorite.

With certain waters it is found that although a suitable degree of precipitation is obtained by the use of the aluminum sulphate the precipitate is of a flocculent, buoyant nature and will not settle. In fact it has a tendency to come to the surface of the water. On examination it will be found that the buoyant tendency of the precipitate is due to small bubbles of carbonic acid gas given off in the reaction between the sulphate of alumina and the earthy carbonates. If the water is soft this tendency is corrected by adding either shortly before the application of the aluminum sulphate, or shortly after, a small quantity of calcium hydrate. This calcium hydrate absorbes the free carbonic acid gas with great avidity and the flocculent precipitate falls to the bottom of the settling basin at as rapid a rate as could be desired.

In the above examples we have mentioned the beneficial action that takes place in the tendency of one set of wastes to neutralize another; the treatment with sulphate of alumina to produce precipitation and sedimentation; the additional treatment by antiseptics to prevent further bacterial action and to inhibit the growth of other objectionable vegetable organisms and the oxidization of the excess of organic matter.

There is still another feature to be considered which is of especial importance on small streams to which at times extremely large quantities of defiling matters may be discharged for short periods of time, and that is the advisability of directly avoiding this extreme contamination, or producing such a degree of dilution that the problem involved is a very slight one.

The writer has in mind a small stream on which is located a paper mill. A few hundred feet below this paper mill is a felt mill drawing its supply from the same stream, the flow of which runs as low in dry weather as one and one-half million gallons per day. At certain irregular periods the digesters containing large quantities of free caustic soda together with the saponified grease, resin, pectin and various other substances extracted from the rags, etc. are discharged into the stream. This proportion of impurities at the time of discharge is so great that the alkalinity of the stream is raised from sixty parts per million to twelve hundred parts and the basin below the dam where the water falls over is frequently filled to a depth of six feet with what appears to be soap-suds.

The effect of alkali upon wool is disastrous and the felt mill experienced great trouble with the soda. They even went to the trouble of stationing a man at their head gate some eight or nine hundred feet above their mill with instructions to close it at such times as he saw the digester discharge coming down. As soon as this substance had passed by, usually a period of not more than twenty minutes, the gate was opened again, the head race holding enough water to supply the mill in the interim. This was manifestly a clumsy way of avoiding the trouble. The real solution of the problem was worked out in the following manner: At the lower end of the head race near the mill a settling reservoir holding a half million gallons of water was constructed at such an elevation that the water flowed by gravity into it. The water for the mill was drawn from the opposite side of the reservoir to the point at which it entered. The amount of strongly alkaline water entering this reservoir was so small in proportion to the entire body of water in it that it not only had no deleterious effect but the alkali actually tended to soften the main body of water in the reservoir.

The point I wish to make in this connection is, that only a small amount of the highly alkaline water enters the reservoir, the major portion of it passing the inlet and going on down stream, the quantity entering the reservoir being such a small portion of the whole body of water that even if it had no beneficial effect it would be so greatly diluted that its treatment would be a very small matter.

The quantity of water required in the various industries is

very great in comparison to the requirements of municipalities. For instance, a supply of two million gallons per day would furnish a town of 20,000 inhabitants, a small paper mill of say twenty tons daily output, a very small bleachery, or a small silk dye-works. The largest silk dye-works in this country consumes 23,000,000 gallons of water per day and a contract has just been let for a bleachery in the New England States requiring a filter plant having a capacity of 36,000,000 gallons per day. This is approximately the amount of water used by the city of Philadelphia west of the Schuylkill. These figures seem stupendous to the person who has not studied industrial requirements.

A pound of muslin, or similar cotton fabric requires in the bleaching process about twenty-seven gallons of water. A pound of paper requires about fifty gallons of water, and a pound of silk not less than one thousand gallons of water. Moreover, many of these processes in which water occupies such an important part include very delicate chemical reactions in which strong acids and alkalies play their part.

The dyeing of silk in the skein is an interesting example of the importance of a sufficiency of very good water. The dyer receives a quantity of silk and some sample colors. Say for instance, one hundred pounds of silk are delivered to him to be dyed a pale blue, and white. He receives instructions to return two hundred pounds of silk. The first operation through which the skein is put is to place it in a bath of soapy water and boil it for a period of time. This removes the natural gum or seracine from the fibre, and after drying it is found that the one hundred pounds of silk now weighs but seventy-five.

The next process is to make this seventy-five pounds of silk weigh two hundred pounds. This is effected by hanging the silk in a bath of bichloride of tin. After a certain period of time the dyer estimates the fibre of the silk has absorbed enough tin to weigh the necessary two hundred pounds. This is not a deposit of a metallic salt upon the fibre but is a chemical combination that has taken place between the fibre and the tin. It cannot be washed off nor out, and practically the only process by which the tin could be separated would be by burning the silk. This bichloride of tin is a very corrosive substance and the silk cannot be handled with the naked hand until after it has

been washed to remove the excess. Washing is effected by hanging the skeins over the revolving rolls of a washing machine against which thousands of needle-like jets of water are directed. After this washing the silk is treated with a dilute solution of sodium phosphate and is again run through the washing machine. If the silk has not taken up enough tin to reach the desired weight it is again placed in the tin bath and the same process is gone through, sometimes a half dozen treatments being required to gain the requisite weight.

The dyeing of the silk, either white or colored, is usually done in a hot soap bath to which the dye is added, and to give additional body to the bath a part of the seracine extracted from the silk in the early part of the process is put in it. It is not customary in this country to bleach silk, the white being produced by dyeing it purple and exhausting the color in an acid bath. This is done by dyeing the silk red and blue and the shade of white eventually evolved depends upon the proportions of red and blue used. This dyeing process is rather mysterious to the uninitiated. The dyes used are not faint reds and blues but when mingled produce an intense purple which, of course, is deposited on the silk. The immersing of these purple skeins in the acid bath and the rapid transition from purple to silvery white is a most interesting and attractive process.

After a period of time in the acid bath during which the scroop, the trade name for that property which gives to silk its rustle, is formed, the skeins are again washed and passed through the hydro-extractor after which they are placed in a steam-tight compartment, stretched under a pull of several thousand pounds and live steam turned in on them for a minute or so. They are then taken out, hung over a smooth stick, twisted, yanked and otherwise mauled by a strong determined man for two or three minutes. This terminates the dyeing process and the dull yellow, linen-like skein, not half as big round as one's wrist has been converted into a silvery fluffy mass of shining fibre at least four times its original bulk, for during the absorption of the weighting materials the silk has increased greatly in volume.

The owner of the silk then receives the two hundred pounds of silk for the one hundred delivered, which seems very much like getting something for nothing until you realize that the dyer

gets anywhere from $1.50 to $3.50 per pound on what he returns for his pay.

It is possible to weigh a pound of raw silk up to sixty ounces, so that little more than twenty per cent. of the fibre itself is silk, the rest being weighting substance. Needless to say the wearing value of such silk is almost nothing.

In the above process large quantities of water are used in the boiling off of the seracine. Soft water is desirable as it prevents the formation of lime soaps. In the washing, after the bichloride of tin bath the water must be absolutely bright and colorless and is preferably hard from earthy carbonates. Any trace of color in this water will be immediately precipitated by the acid upon the silk and produce a stain. Then again, after being placed in the sodium phosphate bath if there were any trace of color or vegetable matter in the water it would be precipitated upon the silk fibre in such a manner as to act as a resist in the subsequent dyeing process with the result that streaky skeins would be produced. This tendency is so strong that even jet black silk will show streaks in it if the water is not perfect.

Perhaps the most important point of all is the acid bath in which most skein silk of every color is placed to produce the scroop. If there is any trace of color in this water to which a small amount of acetic acid has been added, when the skeins are placed in it this color will deposit itself upon the silk in the most incredible manner and a skein dipped a few times in this water will come out very much off color. This tendency of the color to deposit itself on the fibre is so strong that when the water does not appear right to the dyer, without any further instructions he takes a batch of silk which is to be dyed a dark color and runs it first through this acid bath so that all of the color will be precipitated upon it, after which he can place his light colors and whites in it with impunity.

Still another dangerous point is the final washing of the silk after removing it from the acid bath. This wash water must naturally be very pure as otherwise we would have a deposit upon the silk from it.

Until a comparatively recent time nothing but spring or well water was used for the whites and light colors. There is one silk dye-works in Paterson, N. J. that has seventy-five 8 inch

artesian wells, none of which are less than three hundred and fifty feet in depth, all of them drilled through the red sandstone.

So much has been said in this article about forms of contamination by industrial wastes and the benefits of filtered water that possibly a brief description of the two general types of filter plants would be interesting.

There are two kinds of filters, pressure and gravity. Really they are identical in operation, the only difference being in their application. The pressure filter is the same device as the gravity filter excepting that it is placed in an enclosed steel tank and operates under whatever pressure the service main may carry, delivering its water filtered and still under pressure with a loss of head ranging from two to ten pounds, depending upon the make of filter.

The gravity filter on the other hand relies upon the weight of water on it to drive the water through the bed and the water is discharged at the bottom under no pressure.

Taking the detailed parts of a gravity filter plant for an example, we find that they consist of a chemical feed, a settling basin with the necessary baffles, the filter proper and the machinery for washing the filter. As the consumption of every industry varies more or less from moment to moment there are fluctuations in the rate of flow of the raw water coming to the settling basin. The chemical feed must be an apparatus that will regulate whatever chemicals are being applied to meet this fluctuation. For instance, if the feed is set to apply two grains of sulphate of alumina and one-eighth of a grain of calcium hypochlorite per gallon of water it must do that and exactly that, whether the plant is running at full speed, one-quarter speed or a twenty-five per cent. overload. It is a small but vital part of the entire plant and might be compared in its way to the governor of a steam-engine. Of course, chemicals are applied in the form of solutions of a definite strength.

The water after receiving its dose of chemicals flows through the settling tank in a continuous process, in at one end and out at the other. To stop the tendency of the water to flow directly across the basin from inlet to outlet leaving a large eddy on either side, baffles are placed so as to compel the entire body of water to take a circuitous course through the basin. Much of

the solid substance in the water has already been coagulated by the action of one set of impurities upon another, and the applied chemicals have produced further precipitation and have, moreover, gathered together the finer particles of suspended matter into comparatively large masses so that all settle with considerable rapidity toward the bottom of the basin, where they remain until such time as it is convenient to remove them. The hypochlorite used is sufficient to prevent fermentation if the water is highly contaminated with sewage. Moreover, the alum applied has exhausted such remaining dyes as have not been precipitated prior to the time it was added.

Finally the water reaches the far end of the settling basin. It is much clearer, has much less color, the odor has practically disappeared and there seems to be a decided improvement in every way. It is far from being fit for use however. It is then conducted to the filters through the necessary pipes, passes down through them and every trace of suspended matter is removed with the result that a water that three hours before was very dark in color, had a strong odor of sewage and contained much suspended matter is as bright, sparkling and clear as the clearest spring water, and, so far as the senses can determine, is its equal in every way.

The three essential parts of a filter itself are the case, the filter bed proper and the strainer system. The case is of either steel, wood or concrete. The filter bed itself is of carefully selected sand and the strainer system, which consists of a series of pipes leading to all parts of the bed terminating at their outer ends in strainers or sand valves, devices which have slots or perforations of too small a size to permit the sand to pass through, but sufficient in number to allow a definite quantity of water to leave the sand bed. This strainer system is placed on the floor of the filter, and its object is not only to collect the filtered water from the bottom of the filter but also to distribute the wash water uniformly underneath the bed during the washing process.

Considerable quantities of sulphate of alumina and some hypochlorite of lime have been used. As any trace of either of these substances in the filtered water would utterly condemn it for almost every industrial purpose they must be removed or con-

verted into innocuous substances. This is effected in the following manner: Referring first to the sulphate of alumina, a previous analysis of the water has been made which shows the amount of its alkalinity. For every ten parts per million of alkalinity that the water contains one grain of sulphate of alumina per gallon can be used with safety, because this quantity of alkali will combine with the alum to convert it into an insoluble substance, hydrate of alumina, which is readily removed by the filters, and sulphate of lime. In other words, the carbonate of lime existing in the water renders the alum insoluble and converts it into a form in which the filter can hold it. Occasionally we find a water, particularly in the New England States, so soft that it does not possess sufficient alkalinity to permit the use of alum in sufficient quantities to produce the desired result. In such an event an artificial alkalinity is produced by the addition of a small amount of carbonate of soda or by the introduction of corresponding quantities of quick-lime.

Calcium hypochlorite, chloride of lime or bleaching powder, as it is variously known, on being mingled with the organic matter is decomposed into calcium chloride, and ozone is liberated in sufficient quantities to produce the necessary oxidization. Calcium chloride, being an inert salt and existing in such minute quantities has no significance from any industrial stand-point whatever. We thus see elimination of the applied chemicals or their metamorphosis into harmless and insignificant substances.

In addition to economy in the use of chemicals the other costs of operation such as attendance, power, etc. must be reduced to a minimum. One hour per day for each million gallons of water treated is sufficient to cover the attendance of a well designed industrial plant. The sedimentation basins are so arranged that the sludge drains into a channel passing down the middle connecting with a blow-off valve. Opening this valve at intervals of one to six months and permitting the entire chamber to drain takes care of most of the sludge.

The filters must be so designed that they can be washed very rapidly and very thoroughly. This is done by simply reversing the current in the case of the pressure filter and forcing the water up through it at a high rate of speed. This causes the

sand grains to dance up and down rapidly, each scouring the other so that after a few minutes the entire sand bed is cleansed.

In gravity plants an economy in washing can be effected by inducing additional agitation of the sand either by means of a revolving rake or by forcing compressed air under the entire filter bed. Either of these processes produce the same result, that is, very rapid motion of the sand grains and a consequent rapid loosening of the retained impurities.

All types of filters are connected directly with the drain so that wash water can flow to it. Moreover, the first water that comes from the filter after washing is of poor quality and it is customary to filter into the drain for a minute or two or until the filter bed gets thoroughly packed. Depending upon its design, an ordinary filter will wash in from five minutes to an hour's time, and will consume from two to fifty per cent. of the water filtered for washing. The general type of filter used for industrial purposes, however, is designed to be washed very quickly.

From the above it will be seen that the chemical treatment in many industrial problems is as essential as the apparatus itself. Given a properly designed plant employing the proper chemicals, there is no reason why the most polluted American rivers cannot be made satisfactory for all industrial purposes.

The Effect of Mercury Vapor. WERNER VON BOLTON. (*Zeit. Elektrochem.*, xvi, 667.)—A test-tube containing barium amalgam, closed with a vulcanized rubber stopper, was maintained at room temperature for three weeks. The part of the stopper exposed to the amalgam became carbonized, and carbon and microscopic diamonds were found. This carbonization proceeds very rapidly at 100° C. Sulphur hastens the reaction; selenium and tellurium retard it. Vulcanized rubber emits a hydrocarbon gas, which mercury vapor decomposes, as it also does illuminating gas. This decomposition is not preceptible with dried mercury vapor, a definite quantity of moisture seems essential. Mercury vapor also decomposes chloroform, tetrachloride of carbon, carbon disulphide, carbon dioxide and hydrogen sulphide. No reduction to carbon was noticeable when unvulcanized rubber stoppers were used. Probably graphite and diamond were formed in nature by the action of metal vapors, such as iron or magnesium, or carbon dioxide.

THE MEAN DEPTH AT WHICH ROENTGEN RAYS ORIGINATE WITHIN A SILVER TARGET.

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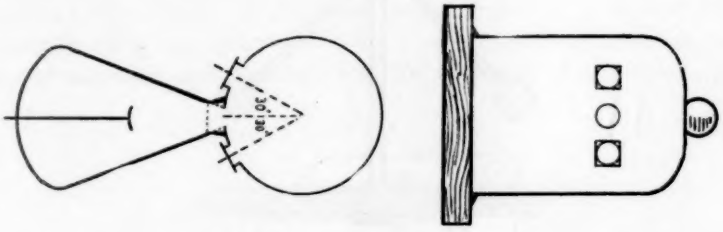
THE modern theory of Roentgen rays states that these rays consist of waves in the ether caused by accelerations received by negatively charged corpuscles during the time in which the cathode rays penetrate the target (or anti-cathode) of the X-ray bulb.

In the *Physical Review,* vol. xxx No. 1, Jan., 1910, Dr. Wm. R. Ham has given a method by which he was able to determine for various potentials the mean depth beneath the surface of a lead target at which the rays originate. In the same

FIG. 1.

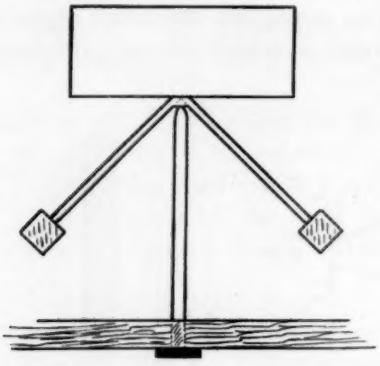


article he shows that the depth at which the rays originate depends on the depth "at which on the average, as many of the cathode particles which have entered the target are suffering accelerations in one direction as in any other." This depth is called the *depth of complete scattering.*

The present research was an effort to determine (*a*) the mean depth at which, for a given potential, Roentgen rays originate in a silver target, and (*b*) to determine the depth of complete scattering for silver at a given potential. Due to a break in the apparatus the completion of the second part of the experiment has been somewhat delayed. The apparatus used was practically the same as was

used by Dr. Ham (see Fig. 1). The X-ray bulb was in the form of a bell-jar of 7 cm. radius and of 16 cm. height. The flange was accurately ground to a plane surface and fitted to a thick plane glass plate. Three holes each 2 cm. in diameter were drilled into the side of the bell-jar at a height of 10 cm. above the flange in such a way that the angular distance along the cylindrical surface of the bell-jar from the centre of one hole to the centre of the next was 30 degrees. Into the central hole was cemented a funnel-shaped tube which held the cathode. The air-pump was attached to this tube. Into the two other holes were ground short glass cylinders. Each of these carried a small glass window. These two windows were cut from the same

FIG. 2.

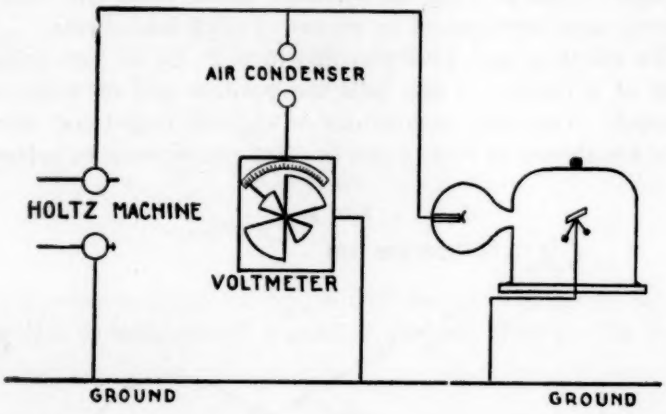


sheet of glass and were of the same thickness. The joints between the windows and their cylinders and between the cylinders and the bell-jar were made air-tight by means of Kotinsky cement. All other joints were made air-tight by means of mercury seals. These joints were so perfect as to hold a good vacuum for several months.

The target (see Fig. 2) was pivoted on an upright post at the centre of the bell-jar so that it could be placed at any desired angle to the cathode stream. Iron balancing weights made it possible to adjust the target magnetically from the outside of the tube. The positions chosen were such that the normal to the target passed through one or the other of the windows

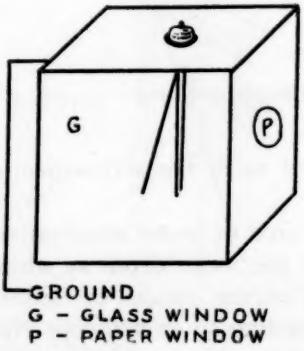
mentioned above, *i.e.* the cathode stream made an angle of 30 degrees with the normal to the target. The tube was excited by means of a 12 plate Holtz machine electrically driven. Fig.

FIG. 3.



3 shows the scheme of electrical connections. A gold-leaf electroscope (Fig. 4) provided with a micrometer-microscope was placed opposite each window and the amounts of the discharges

FIG. 4.

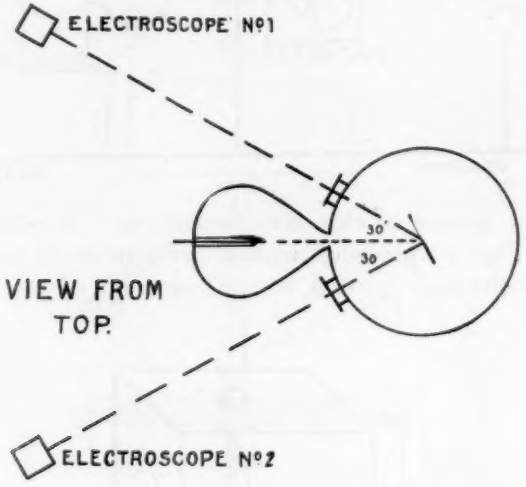


were taken as proportional to the intensities of the X-rays. Each electroscope was cubical in shape and was made of sheet brass. Two large glass windows and one small paper window were provided in each as shown in the figure. An 8 c. p. incandescent

bulb was placed near one of the windows to illuminate the gold leaf. The microscope was placed so as to point towards the opposite window and its scale was thus illuminated directly by the lamp above mentioned. The X-rays were admitted through the paper window. All rays except those from the uniform windows were screened off by means of thick lead sheets.

The electroscopes were charged to a P. D. of 340 volts by means of a battery of dry cells the positive end of which was grounded. The relative positions of cathode target and electroscopes are shown in Figs. 5 and 6. For convenience of reference

FIG. 5.



the parts are lettered as in the above-mentioned article by Dr. Ham.

Let o be the source of some ether pulse and let o be so situated as to be at the mean depth at which X-rays originate.

Let $l_1 - l_2 = x =$ the excess of silver which the pulse has to traverse in passing to electroscope No. 1 over that which it traverses in passing to No. 2.

Let h be the perpendicular distance from o to the surface of the target.

Let d be the distance from o to the point at which the cathode ray enters the target.

Let θ_0 be the angle which the lines from the electroscopes to the target make with the cathode-ray stream.

Let θ be the angle which the normal to the target makes with the cathode ray stream.

Then $$x = h\left(\frac{1}{\cos(\theta_0+\theta)} - \frac{1}{\cos(\theta_0-\theta)}\right).$$

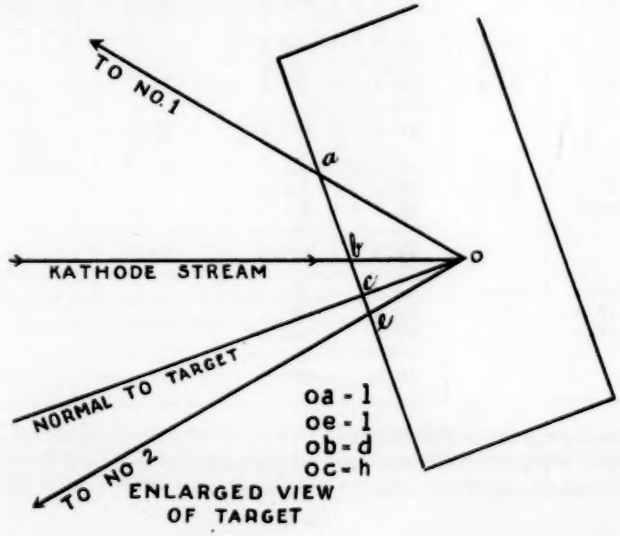
But $$h = d\cos\theta.$$

Therefore $$x = d\cos\theta\left(\frac{1}{\cos(\theta_0+\theta)} - \frac{1}{\cos(\theta_0-\theta)}\right),$$

or $$x = dF(\theta, \theta_0).$$

It is evident from the figure that the rays going to electroscope No. 1 must travel a greater distance through the target

FIG. 6.



than must the rays going to electroscope No. 2. They will therefore suffer more absorption. If I_0 represents the intensity of the ray going towards No. 2 at the moment of emergence from

the target, and if I represents the corresponding intensity of the ray going towards No. 1, then

$$I = I_0 \varepsilon^{-\lambda x}$$

where x is defined as above and λ is the coefficient of absorption. λ is found experimentally for each potential used. I and

TABLE I.

TO FIND THE COEFFICIENT OF ABSORPTION OF SILVER FOR X-RAYS GENERATED FROM A SILVER TARGET AT A POTENTIAL OF 17,000 VOLTS.

Time	Discharge		Discharge cor. for natural leak		No. 1 cor. for calibration	Per cent. remaining after absorption
Min.	No. 1	No. 2	No. 1	No. 2		
21	26.7	89.8	25.8	88.8		
24	27.9	90.2	26.8	89.0		
28	29.8	93.0	28.7	91.7		
			81.3	269.5	86.7	32.1
24	26.9	90.6	25.8	89.4		
24	29.0	94.6	27.9	93.4		
24	27.3	88.1	26.2	86.9		
			79.9	269.7	85.3—	31.6
22	29.1	92.0	28.1	90.9		
22	26.9	88.0	25.9	86.9		
25	29.6	92.2	28.5	91.0		
			82.5	268.8	88.0	32.7
21	26.4	90.0	25.3	89.0		
22	28.5	88.8	27.5	87.7		
22	28.1	90.1	27.1	89.0		
			79.9	265.7	85.3—	32.1

Average per cent. remaining, 32.1.
Greatest deviation from average, 1.9 per cent.
Thickness of absorption sheet $= x = 0.00263$ cm.

$$I = I_0 \varepsilon^{-\lambda x}$$
$$\lambda = 432.1$$

I_0 are directly proportional to the readings of the electroscopes. Therefore x is known. The value of d may then be calculated

from the equation $x = d\,F\,(\theta_0,\theta)$. For the actual angles used $F\,(\theta_0,\theta) = 0.866$ so that

$$d = \frac{x}{0.866}.$$

The electroscope discharges were corrected for the natural rate of leak. By simultaneously determining the amounts of the discharges under exactly similar conditions the ratio between

TABLE II.

TO FIND THE COEFFICIENT OF ABSORPTION OF SILVER FOR X-RAYS GENERATED FROM A SILVER TARGET AT A POTENTIAL OF 10,000 VOLTS.

Time	Discharge		Discharge cor. for natural leak		No. 1 cor. for calibration	Per cent. remaining after absorption
Min.	No. 1	No. 2	No. 1	No. 2		
71	21.0	87.8	17.9	84.4		
72	22.0	87.8	18.8+	84.3		
74	22.0	88.1	18.7+	84.8		
			55.4+	253.5	59.1	23.3
83	20.6	84.4	16.9	81.4		
80	20.3	85.1	16.8	81.3		
71	19.9	82.9	16.8	79.5		
			50.5	242.2	53.9	22.3−

Average per cent. remaining, 22.8.
Greatest deviation from average, 2.2 per cent.
Thickness of absorption sheet $= x = 0.00263$ cm.

$$I = I_0\,\epsilon^{-\lambda x}$$
$$\lambda = 562.1$$

Summary of results on coefficient of absorption.
At 17,000 volts, $\lambda = 432.1$ } for absorption of rays from a silver target by a
At 10,000 volts, $\lambda = 562.1$ } sheet of silver.

their readings was determined. Then by means of this ratio the corrected reading of No. 1 was expressed in terms of the reading that would have been shown by No. 2 under similar conditions.

Average rate of natural leak of electroscopes:

Electroscope No. 1.....0.044 divisions per minute.
Electroscope No. 2.....0.048 divisions per minute.

Calibration of electroscopes under similar conditions:

Rays generated by lead target.

1.065 (X-rays generated at 17,000 volts)
1.065
1.068 (X-rays generated at 10,000 volts)

1.066 mean.

Rays generated by silver target.

1.073 (X-rays generated at 17,000 volts)
1.068
1.058 (X-rays genertaed at 10,000 volts)
1.065

1.066 mean.

$$\text{Weighted mean} = \frac{\text{No. 2}}{\text{No. 1}} = 1.067.$$

FINAL RESULTS.

At 17,000 volts, x=0.000080 cm.
At 17,000 volts, d=0.000092 cm.
At 10,000 volts, x=0.000047 cm.
At 10,000 volts, d=0.000054 cm.

$$\frac{10,000}{17,000} = 0.59-. \qquad (1)$$

$$\frac{0.000054}{0.000092} = 0.59-. \qquad (2)$$

From (1) and (2) it is seen that the mean depth at which X-rays originate within a silver target is directly proportional to the potential employed in generating the rays.

In conclusion I desire to thank Dr. Wm. R. Ham for his continual assistance and his helpful suggestions during the course of the experiment. Thanks are also due to Mr. F. C. Miller for valuable aid rendered during the progress of the work.

TABLE III.

To FIND THE MEAN DEPTH AT WHICH X-RAYS ORIGINATE IN A SILVER TARGET (*a*) WHEN THE RAYS ARE PRODUCED AT A POTENTIAL OF 17,000 VOLTS, (*b*) WHEN THE RAYS ARE PRODUCED AT A POTENTIAL OF 10,000 VOLTS.

P. D. = 17,000 VOLTS.

Time	L* R†	Discharge		Discharge cor. for natural leak		Calibration	Final No. 1	$\frac{I}{I_0} = \varepsilon^{-\lambda x}$
Min.		No. 1	No. 2	No. 1	No. 2			
26	L	81.0	89.7	79.9	88.5	1.073	85.8	0.969
25	R	79.6	82.7	78.5	81.5		84.2	0.967
27	R	77.7	80.0	76.5	78.7		81.3	0.963
23	L	77.7	86.0	76.7	84.9	1.068	81.5	0.965 —
							Mean,	0.966

P. D. = 10,000 VOLTS.

61	L	82.8	91.0	80.1	88.1	1.065	85.3	0.968
67	R	84.9	88.4	82.0	85.2		87.3	0.976
72	R	84.1	87.1	80.9	83.6	1.058‡	86.2	0.970
76	L	83.2	90.1	79.9	86.5		85.1	0.984
							Mean,	0.974

* Readings marked L were taken with the normal to the target making an angle of 30 degrees to the left of the kathode stream.

† Readings marked R were taken with the normal to the target making an angle of 30 degrees to the right of the kathode stream.

‡ The value 1.066 was used in calculation as there was noticed to be some fluctuation in the voltage while the last reading was being taken.

The calibration $\left(=\frac{\textit{reading of No. 2}}{\textit{reading of No. 1}}\right)$ was found *for each pair* of readings as follows, $\frac{1}{2}\left(\frac{\textit{reading of No. 2 } L}{\textit{reading of No. 1 } L}+\frac{\textit{reading of No. 2 } R}{\textit{reading of No. 1 } R}\right)$.

Average rate of natural leak of electroscopes:

Electroscope No. 1.....0.044 divisions per minute.
Electroscope No. 2.....0.048 divisions per minute.

Calibration of electroscopes under similar conditions:

Rays generated by lead target.

1.065 (X-rays generated at 17,000 volts)
1.065
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1.066 mean.

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1.068
1.058 (X-rays genertaed at 10,000 volts)
1.065

1.066 mean.

$$\text{Weighted mean} = \frac{\text{No. 2}}{\text{No. 1}} = 1.067.$$

FINAL RESULTS.

At 17,000 volts, x=0.000080 cm.
At 17,000 volts, d=0.000092 cm.
At 10,000 volts, x=0.000047 cm.
At 10,000 volts, d=0.000054 cm.

$$\frac{10{,}000}{17{,}000} = 0.59-. \qquad (1)$$

$$\frac{0.000054}{0.000092} = 0.59-. \qquad (2)$$

From (1) and (2) it is seen that the mean depth at which X-rays originate within a silver target is directly proportional to the potential employed in generating the rays.

In conclusion I desire to thank Dr. Wm. R. Ham for his continual assistance and his helpful suggestions during the course of the experiment. Thanks are also due to Mr. F. C. Miller for valuable aid rendered during the progress of the work.

TABLE III.

To Find the Mean Depth at which X-rays Originate in a Silver Target (*a*) when the Rays are Produced at a Potential of 17,000 Volts, (*b*) when the Rays are Produced at a Potential of 10,000 Volts.

P. D. = 17,000 VOLTS.

Time	L* R†	Discharge		Discharge cor. for natural leak		Calibration	Final No. 1	$\frac{I}{I_0}=\varepsilon^{-\lambda x}$
Min.		No. 1	No. 2	No. 1	No. 2			
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72	R	84.1	87.1	80.9	83.6	1.058‡	86.2	0.970
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The calibration $\left(=\frac{\textit{reading of No. 2}}{\textit{reading of No. 1}}\right)$ was found *for each pair* of readings as follows, $\frac{1}{2}\left(\frac{\textit{reading of No. 2 } L}{\textit{reading of No. 1 } L}+\frac{\textit{reading of No. 2 } R}{\textit{reading of No. 1 } R}\right)$.

Formation of Nitric Oxide in High Tension Arcs. F. HABER, A KOENIG, and E. PLATON. (*Z. Elektrochem.*, xvi, 789.)—With a continuous arc a maximum percentage of nitric oxide (8.16) was obtained when the pressure was about 150 mm. At higher pressures the arc did not fill the quartz tube, and the effect of water cooling was diminished. With alternating current the power efficiency was determined. The power factor was ascertained with a current of not too high frequency by a Dolezalek electrometer. The best yield with 0.7 kilowat was 57 Gm. of nitric acid per kilowatt hour, the concentration nitric oxide was 3.4 per cent.

The Future of Aerial Navigation. (*Amer. Mach.*, xxxiii, 745.)—The repeated accidents with flying machines, both aeroplanes and dirigibles, culminating in the disaster to the Zeppelin VI, lead to the conclusion that in spite of wonderful technical progress, little has been done toward surmounting the inherent dangers. The dirigible would seem essentially the safer type. Nevertheless five Zeppelin airships have been destroyed, three by a gale of wind and one by an explosion of the motor. The achievements of the Wright brothers are epoch-making in their importance, but from the commercial point of view, even assuming they can be rendered fairly stable by the use of gyroscopes or other devices, the uneconomic use of power seems a serious drawback to their development. The aeroplane is probably capable of greater speed than any form of land transportation, which puts it in a class by itself for certain purposes, such as army scouting and possibly offensive attack; but much remains to be done before it can be considered a commercial vehicle in any sense.

Colloidal Silver as an Intensifying and Toning Agent in Photography. A. NEUGSCHWENDER. (*Z. Chem. Ind. Kolloide*, vii, 214).—When silver ferrocyanide is treated with stannous chloride solution and then with ammonia solution, a dark brown solution is obtained, from which a precipitate of colloidal silver separates after some time. This reaction can be utilized for intensifying or toning of photographic images, the silver being first converted into ferrocyanide by treatment with an alkaline ferrocyanide. The intensification produced is greater than that obtained with mercury and ammonia, but less than that from uranium. Dark brown tones are obtained on bromide paper, which can be converted into bright brown and red brown tones by subsequent treatment with dilute hydrochloric acid or ammonium chloride solution. When stannous nitrate and sodium carbonate are used instead of stannous chloride and ammonia, the intensification is stronger, but still less than that produced by uranium. Other amorphous silver compounds are converted into colloidal silver by stannous salts and alkalies, but the ferrocyanide process appears the only one which can be used in photography.

THE NEW IRONCLAD-EXIDE BATTERY FOR ELECTRIC VEHICLES.

BY

MR. L. H. FLANDERS,

Engineer, Electric Storage Battery Co., Philadelphia.

(*Abstract of Paper Presented at the Special Meeting of the Electrical Section, held Tuesday January 3, 1911.*)

INTRODUCTION.—The very simplicity of the electric vehicle at first tended to retard its development, no fundamentally new type of construction being deemed necessary. A battery and a motor on an ordinary vehicle made a horseless carriage.

An appreciation of what can be accomplished with properly designed electrics has now been gained. This has been largely the result of a still growing spirit of co-operation between the vehicle maker, the battery maker, the central station, and the user, which has led each to study the general situation and to try and adapt his special part to the best interest of the whole. The result is the rapid increase in the use of electric vehicles—both pleasure and commercial.

BRIEF HISTORY OF LEAD STORAGE BATTERY.—The battery generally manufactured for vehicle propulsion is of the lead sulphuric acid type. This type was discovered by a Frenchman, Gaston Planté, in 1860. It includes both the Planté and pasted types. To the Planté type belong all those lead batteries whose active material is obtained by means of chemical or electrochemical corrosion of the lead support plates, and whose electrolyte is a solution of sulphuric acid in water. Various modifications of the Planté type have been tried for vehicles with moderate success.

The pasted type, developed almost simultaneously in 1880 by Camille Faure in France, and Charles Brush in this country, is now generally used for electric vehicles. It includes all those batteries in which the active material consists of a paste made of lead oxide applied to a grid.

THE EXIDE BATTERY.—In the development of the lead sulphuric acid battery for vehicle service the problem has always been to secure high capacity per unit of weight consistent with

durability. Although previously made spasmodically the earliest application of the battery to the electric vehicle on a large scale was made in the late nineties, with the chloride accumulator, a modified form of the Planté type. Although at the time this was considered successful, and long experience has proved its durability, yet greater capacity per unit of weight soon became necessary.

To meet this need the "Exide" battery was introduced in 1900, and since that time has been a most widely used battery for automobile propulsion. Although improved from time to time it has remained unaltered in its essential principles. As this battery is so widely known, time will not be taken to further describe the details of its construction, except such features and characteristics as bear upon the further development of storage batteries for vehicle use.

Among these is the form of grid made of a stiff lead alloy to give strength and resist corrosion. Its principal feature is the cage structure to hold the active material firmly in place in the form of a narrow vertical ribbon between vertical conducting ribs. This feature is used in all sizes and thicknesses of Exide plates, both positive and negative. The ribs and cross bars of the negative grid are lighter than those of the positive.

The positive and negative plates are made by pasting the grids with lead oxides and treating them electrochemically to produce a lead peroxide in the positive plate and spongy lead in the negative plate.

The Exide vehicle battery plates are manufactured in two standard sizes and several thicknesses, one of these being the Hycap Exide. The rating for plates known as Exide is based on a four-hour rate of discharge which is roughly one ampere per pound of complete cell. The capacity of the Exide plate rapidly rises in service and then gradually falls off. However, the initial rating is conservative, so that if a battery be given its proper initial charge it will give the rated four-hour discharge at the start. This will gradually increase in use to four and a half and even to five hours at the same rate of current. The increase to a maximum is more rapid than the dropping off from the maximum. This rapid rise in capacity at the beginning of service is due to the increasing porosity of the positive active material. This results in better diffusion of the electrolyte, which

brings more of the lead peroxide into action on each cycle of charge and discharge. However, this rise in capacity is at the expense of active material. For, as more material is brought into action, the active mass softens and then when the battery is charged some of the material is dislodged and settles to the bottom of the cell in the form of sediment. Incidentally this explains why the life is shortened by too much charging. The capacity will increase as long as the rate of increase in the porosity is greater than the rate at which the active material is lost, but, finally, the loss of material will increase faster than the gain in porosity. When this condition is reached the cell will begin to lose capacity.

POSSIBILITY OF FURTHER DEVELOPMENTS OF THE LEAD STORAGE BATTERY.—From the foregoing discussion of the life of the Exide positive plate, it is evident that if the positive active material could be prevented from being detached from the supporting grid and still be retained in a healthy and operative condition, the plate would have a very much longer life.

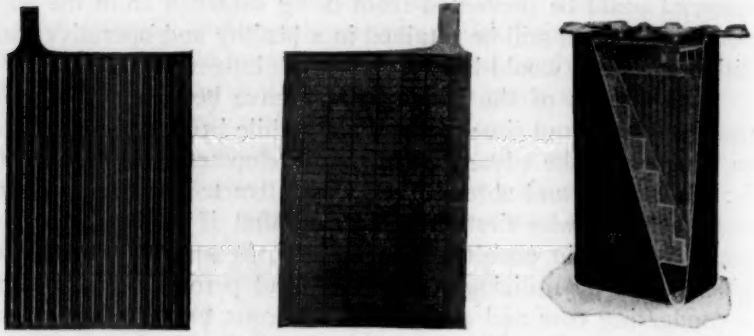
The makers of the Exide battery have been improving the positive plate from time to time, and, while bending every effort to study and take advantage of the development of the art both in this country and abroad, they were attracted by the claims of a Frenchman who first demonstrated that if positive material could be kept in position it would remain active. He accomplished this by utilizing a pencil of lead peroxide surrounding a conducting core and exclosed in a porous tube of such elastic quality that as the active material expanded and contracted, due to changes in its molecular structure, the circular tube compensated for these variations. Thus the positive material was protected and held in position. At the same time this form comprising, as it does, a central conducting core embedded in a cylindrical pencil of peroxide of lead, provides excellent conductivity and increased accessibility for the electrolyte, thereby rendering it possible to obtain a relatively high output from a relatively small quantity of active material.

The makers of the Exide battery, after a careful investigation of this new battery, secured the American patent rights. For several years they have been actively but quietly carrying on a process of development in order to adapt the original form, which was somewhat crude and frail, to the demands of com-

mercial use. As a result, they have developed a battery with a positive plate which not only possesses all the desirable characteristics of the Exide positive, but which has even a greater capacity per unit weight and which is so constructed that the loss of its active material is reduced to a minimum. On account of its remarkable durability, this battery is called the Ironclad-Exide.

THE IRONCLAD-EXIDE BATTERY.—The positive plate of the new battery (Fig. 1) consists of an alloy framework, comprising top and bottom bars integrally connected by conducting cores of the same material. Surrounding these cores are the uniform pencils of active material protected by horizontally laminated rubber tubes. Each tube is formed with two narrow vertical ribs diametrically opposite each other which take the place of the

FIG. 1. FIG. 2. FIG. 3.



spacing ribs on the ordinary wood separator, and, at the same time, give added strength and durability to the tube.

The negative plate (Fig. 2) is of the same general construction as the regular Exide negative, but it has been made somewhat thicker in order to withstand the longer life of the Ironclad positive. The outside negative plates are thinner than the inside negatives. Both the positive and negatives of the Ironclad-Exide are made in the two standard sizes MV and PV.

The plate lugs have the same dimensions as those of the Exide plates of regular thickness, and the plate centre spacing is the same.

The wood separator used with this battery is a thin sheet of chemically treated wood, flat on both sides.

The pillar straps for connecting the plates are similar to the standard Exide pillar straps. An improvement in detail is that the top of the pillar is bevelled, which facilitates burning the connecting straps.

A feature of the Ironclad-Exide battery is the flexible pillar strap connector. It consists of alloy terminals cast around lead-plated copper strips which give great conductivity and flexibility, and are replaced even more easily than the stiff pillar strap connectors used with Exide batteries. These flexible connectors are standard with the Ironclad-Exide.

Fig. 3 shows an assembled cell cut away to show construction. The jar is the same as that used for the Exide cell. The positive and negative plates are separated by the thin flat wood separators. No rubber separators are required since the positive plate provides its own separator in one of its essential features—the rubber tubes with the ribs thereon. Otherwise the method of assembling is exactly the same as that developed through long experience and employed for Exide batteries.

CHARACTERISTICS OF THE IRONCLAD-EXIDE.—The Ironclad-Exide elements are interchangeable with Exide elements. Users of Exide batteries who desire to take advantage of the increased capacity and life of the Ironclad-Exide can therefore substitute Ironclad-Exide elements for Exide elements without discarding any of the other parts of their batteries. Obviously, these elements may be put into any existing battery, having jars of appropriate size. To give a concrete example, a twenty-four-cell nine MV Exide battery, weighing approximately 720 pounds complete, including trays, and rated at 28 amperes for four hours, will receive nine MV Ironclad elements. It then will weigh approximately 740 pounds, with an initial rating of 28 amperes for four and a half hours, or 30 $^{2}/_{3}$ amperes for four hours.

The rating is conservative, yet, when compared with the Exide positive, which is rated at 7 amperes for four hours, there is an increase of 12.5 per cent. in initial rating.

This battery, like the Exide, has the well-established advantages of the best lead storage batteries: high discharge voltage and high efficiency.

The same conservative rating is applied to the Ironclad-Exide as is applied to the Exide battery. Using the four-hour rating of the MV Exide, which has been taken as a standard in our

previous discussions, at the same rate of discharge current per positive plate (that is, 7 amperes) the Ironclad-Exide battery, weighing but little more, will start in at four and a half hours, which is an initial increase of 12.5 per cent. in ampere hours output. It will reach a capacity of from four and three-quarters to five hours within about 25 discharges, and from five and a half to six hours within about 200 discharges. It will then retain a capacity above its rating for practically its entire life, in some cases reaching over 1000 cycles before dropping below its four and a half hour rating. The weight efficiency of the Ironclad-Exide will vary somewhat with the size of battery, mounting, and number of cells. A twenty-four-cell nine-MV Ironclad-Exide battery, arranged in three trays to the best advantage would weigh approximately 740 pounds. The initial capacity at the four and a half hour rate, would be about 8 watt hours per pound of complete battery, increasing to a probable capacity of over 11 watt hours per pound of complete battery.

OPERATION OF THE "IRONCLAD-EXIDE."—For the present, the Ironclad-Exide batteries are being assembled and charged only by the manufacturer. The instructions for their operation are even more simple than those for the Exide batteries.

Besides publishing detailed instruction books, the maker of the Ironclad-Exide battery has established many Exide depots and has provided inspectors to co-operate with the vehicle manufacturers, salesmen, and central stations in a general campaign of education. Users of pleasure vehicles who charge their own batteries are urged to take their cars periodically to an Exide depot for inspection or to have one of the travelling inspectors call on them when in their neighborhood or to consult the central station from which they purchase current in case there are any matters connected with operation not clear to them. Difficulties sometimes arise from the false ideas of fixed voltage and fixed specific gravity. Also a disorder may be attributed to the battery when some mechanical part of the vehicle is at fault.

Give the mechanical parts of the electric car even a fraction of the care demanded by those of the gasoline car, instead of the almost total neglect often accorded them.

To determine whether trouble is in the mechanical parts or in the battery, the ampere-hour meter is sometimes useful, since it measures the output of a battery and the amount of current put

into it. For instance, a car travelling a given route taking more ampere-hours than when previously travelling over the same route, under similar conditions, must have something wrong with its mechanical parts. Thus the ampere-hour meter is a valuable check, though the mistake of relying entirely upon its detection of trouble must not be made.

The keynote to successful operation is system in the observance of the following salient points, which are here briefly touched upon:

1. Keep the electrolyte above the tops of the plates.
2. Add pure water in replacing evaporation, never acid.
3. When a battery is discharged, and especially when a vehicle is stalled, resulting in over discharge, charge as soon as possible.
4. Do not overcharge unnecessarily, although by overcharging the Ironclad-Exide battery will not suffer damage to the same extent as other lead batteries.

Formerly, great stress has been laid upon frequent and systematic cleaning; but the "Ironclad-Exide" will rarely, if ever, require cleaning, since its active material is so firmly held in place, and consequently the rate of sediment deposit is extremely slow. "To determine whether it will be necessary to remove the sediment it is advisable after the battery has been charged 250 times, to cut out for inspection one cell from the centre of the battery. Then from the height of the sediment, estimate its rate of deposit, allowing a sufficient margin in making the estimate to ensure cleaning *before the sediment can possibly reach the plates and* shorten their life by short-circuiting them."

ADVANTAGES OF THE "IRONCLAD-EXIDE."—The "Ironclad-Exide" battery has the inherent advantages peculiar to the lead sulphuric acid type. Among them are:

1. The use of dilute sulphuric acid as an electrolyte.
2. High individual cell voltage.
3. Low internal resistance.
4. High watt-hour efficiency.
5. Relatively small variation between the average voltage of charge and discharge.
6. Ability to discharge at very high energy rates with quick recovery.
7. Low temperature coefficient for temperature correction;

that is, it is effected, but relatively little by temperature changes.

8. Increased capacity at diminished rates.

In addition, because of its particular construction, the "Iron-clad-Exide" battery has the following advantages over the best of other types of lead vehicle batteries, the "Exide" being taken as standard:

1. It gives from two to three times the life.

2. It rarely, if ever, requires cleaning.

3. It will give greater mileage per charge, which considering its longer life and greater percentage rise in ampere hours' capacity per discharge, will mean in a given vehicle upwards of three times the total mileage obtained with the corresponding size of "Exide" battery.

4. These advantages lead, in any given vehicle, under the same conditions of operation, to a substantial reduction in the cost of battery maintenance.

Pinch-effect Steel Furnace. A. L. QUENEAU. (*Amer. Electrochem. Soc.*, xvii, 131.)—The pinch-effect is turned to useful account. The fused metal fills the bath of the furnace and two legs extending downward from it, slightly inclined outward. Electrodes are inserted at the bottom of these legs, and a large electrode is suspended above the bath. The metal in the legs is subjected to the hydrostatic pressure of the fused steel above it, and the current is so proportioned that a series of pulsations is set up leading to disruption and re-establishment of the continuity of the molten metal. The experimental furnace takes charges of 225 kg. C. A. Hansen considered any encouragement of the pinch-effect dangerous and thought the lining of the legs of magnesia and pitch would not last, as it became cheesy at steel-bath temperatures. Alundum too, was unsuitable for a lining.

A Good Waterproof Glue. (*Amer. Mach.*, xxxiii, 742.)—This is made as follows:

India rubber	1 part
Mineral naphtha or coal tar	12 parts

heat gently and mix and add

Powdered shellac	20 parts

Pour on a slab to cool; when used heat to 250° F.

SOIL ORGANIC MATTER AS MATERIAL FOR BIOCHEMICAL INVESTIGATION.*

BY

OSWALD SCHREINER and EDMUND C. SHOREY.

(From the Laboratory of Fertility Investigations, Bureau of Soils, United States Department of Agriculture, Washington, D. C.)

EVERY soil investigator, whether chemist, or bacteriologist, or physicist, studying some special problem, or the agronomist, dealing with the general relation of soils to crops, sooner or later encounters difficulties that have their origin in the lack of knowledge of the chemical composition of the organic matter of the soil.

Some organic matter is essential to make a soil of what would otherwise be pulverized and more or less hydrolyzed rock, and while there are some soils capable of growing crops that contain very small quantities of organic matter, on the whole the quantity of this material in average soils is considerable. Analyses have shown that the average organic content of the soils of the United States is 2.06 per cent. and of subsoils 0.83 per cent.

It is known that the organic matter of soils has its origin in the remains of plants and animals, the former probably predominating greatly, and with the knowledge available regarding the great number of organic compounds present in the tissues of the living plants and animals, it might very well be assumed that soil organic matter would also be made up of many compounds. While, however, there has been no disposition to question the diversity of the organic material from which soil organic matter is formed, there has been an assumption on the part of many that in some mysterious way this conglomerate of plant and animal compounds becomes transformed in the soil into a

* Presented at the Minneapolis meeting of the American Association for the Advancement of Science and published by permission of the Secretary of Agriculture.

single group of closely related compounds, humic acid, etc., and that no matter how varied may be the organic remains or diverse the conditions of decay, soils vary in organic matter chiefly in quantity.

In contrast to this is another view somewhat common in agricultural literature, that the organic matter of soils is of a very complex nature regarding which very little is known. Little fault can be found with this statement in itself, but it is often made in such a way as to convey the impression that not only do we know little regarding it, but it is almost hopeless to attempt any investigation of it. There is, moreover, seldom coupled with this confession of ignorance any appreciation of the importance of a thorough knowledge of the chemical composition of this important soil constituent.

In considering the importance of a more thorough knowledge of the organic matter of soils, it should be borne in mind that it is material that is for the most part the result of change and that much, perhaps all of it, is susceptible of still further change; that is, it is in a transition stage. The changes which it has undergone and which it may still undergo are determined by a number of factors, chief of which are moisture, aeration, character of microörganisms and the mutual relation of the organic compounds and the mineral constituents. These factors are many of them influenced or controlled by the cultural methods used in practical agriculture including fertilizing, drainage, irrigation, inoculation, etc. Since, then, the common agricultural methods used by farmers are also operations that influence the changes which soil organic matter undergoes, it is plain that the treatment to which this material is subjected under these methods is in part chemical treatment. There can be intelligent chemical treatment of any material only when the chemical nature of the material is known. It is not necessary that the practical agriculturist should know the chemical names or formulas of the organic compounds in the soil, but to the scientific investigator to whom the farmer looks for the "why" of agricultural operations such knowledge is necessary because it carries with it a knowledge of their properties.

The importance of a knowledge of the chemical character of the organic matter of the soil may be considered under four

heads: its effect on crops, its effect on the bacteria and fungi of the soil, its influence on the physical properties of the soil, and its relation chemically to the mineral ingredients of the soil.

It is a well established fact that some chemical compounds which occur in plants and may get into the soil are harmful to growing plants when presented in water solution to the roots. It has also been shown that some organic compounds that occur in soils and have been isolated from them are also harmful to growing plants under these conditions. On the other hand, plants may take up other organic compounds when presented to their roots in water solution without injury to the plant or in the case of some nitrogenous bodies with benefit. Now while the organic matter of soils is for the most part little soluble in water, a water extract of soils always contains some organic matter. In consequence organic compounds have always to be considered as a portion of the material in the nutrient solution supplied to crops growing in the soil.

The chief function of bacteria and fungi is to act on the higher organic compounds from living organisms and convert them into simpler compounds. In other words, these higher compounds are the food of the microörganisms. The simpler compounds resulting from the activity of the fungi and bacteria, commonly spoken of as the products of decay or fermentation, are in part at least still organic substances and help to make up this portion of the soil. No fact regarding bacteria is better established than that they are influenced not only in habit of growth, but also in the character of the compounds produced, by the chemical composition of the medium in which they are grown and are generally intolerant of the presence of an excess of their own by-products. The soil organic matter impregnated with the soil solution is then the culture medium on which soil microörganisms have to grow and contains also the products of their growth. Bacteria, the activity of which is beneficial to crops, may fail to flourish because the food supplied them is not suitable or because their own products or the products of other forms hinder their growth. On the other hand, the activity of harmful bacteria, fungi, or protozoa may be stimulated by an abundant supply of suitable food. The necessity then of some chemical knowledge of this culture medium and by-products,

in any study of the mutual relation of soil microörganisms to each other or to crops, is apparent.

The properties of soils generally included under the term physical, such as water-holding power, heat conductivity, absorption, granulation, are universally recognized as potent factors in determining the character of a soil and its adaptability to the growing of crops. In considering these factors the tendency has been to consider the soil simply as an aggregate of mineral particles of different sizes and consequently different surface area, and to correlate the varying physical properties with this variation. That this view is wholly inadequate is evident, for solid organic matter may also be present in particles of different sizes and these may have different physical properties due not only to variation in size, but probably much more so to difference in chemical composition and structure. Furthermore, the organic matter may and in fact generally does play an intimate part in the behavior of the mineral particles entering into chemical combination, coating them or cementing them together. It is evident then that there can be intelligent study of the influence that the organic matter of the soil has on its physical properties only when the chemical identity of its several components is known.

The great majority of organic chemical compounds are reactive toward inorganic compounds, acids, bases, and salts. Organic acids can form salts with mineral bases, or double salts with mineral salts. Organic bases form salts with mineral acids and quite a number of organic compounds combine both acid and basic properties and form organic compounds with both mineral acids and bases. Such being the case, there necessarily exists a mutual relation between the organic compounds in the soil and the mineral particles which form its foundation. Some of the acids isolated from soils could not exist free for any time in a soil containing free bases or salts of weak acids such as carbonic acid, and there is abundant evidence that many of the organic compounds exist in the soil in mineral combination. In fact, the relation between the organic and mineral particles of the soil is so intimate that any differentiation of soil chemistry into organic and inorganic should not be used as the basis of any theory or line of argument regarding soil phenomena or soil treatment.

TABLE I.

Method of separation.					Class.	Compound isolated and identified.
Alkaline extract	Humus precipitate	Soluble in alcohol	Soluble in petroleum ether	Insoluble in cold alcohol	Acids	α—Hydroxystearic acid.[1]
				Soluble in cold alcohol	Acids	Paraffinic acid.[2]
					Fats	Liquid glycerides.[3]
			Insoluble in petroleum ether		Resinous bodies	Resin acids. Resin esters.
		Insoluble in alcohol.				
	Acid filtrate	Shaken out by ether			Acids	Dihydroxystearic acid.[4]
		Precipitated by silver nitrate in neutral solution			Acids	Picoline carboxylic acid.
		Precipitated by silver nitrate in alkaline solution			Pyrimidine derivatives	Cystosine.[6]
					Hexone bases	Histidine.[7] Arginine.[8]
		Precipitated by lead acetate in alkaline solution			Pentosan	Xylan.[9]
		Precipitated by copper sulphate and sodium bisulphite			Purin bases	Xanthine.[10] Hypoxanthine.[11]
Hot alcohol extract	Insoluble in cold alcohol, saponified	Soluble in petroleum ether	Insoluble in cold alcohol		Hydrocarbons	Hentriacontane.[12]
			Soluble in cold alcohol		Cholesterol compounds	Phytosterol.[13] Agrosterol.[14]
		Insoluble in petroleum ether			Acids	Agroceric acid. Lignoceric acid.[15]
	Soluble in cold alcohol	Water soluble.				
		Water insoluble	Ether insoluble	Ammonium carbonate soluble	Resinous bodies	Resin acid I.
			Ether soluble	Sodium carbonate, soluble	Resinous bodies	Resin acid II.
				Sodium hydrate, soluble	Resinous bodies	Resin acid III.
				Undissolved	Resinous bodies	Resin ester.

[1] Jour. Am. Chem. Soc., xxxii, 1674 (1910); [2] *idem*, xxxii, 1677 (1910); [3] *idem*, xxxiii, 78 (1911); [4] *idem*, xxx, 1599 (1908); [5] *idem*, xxx, 1295 (1908); [6] Jour. Biol. Chem., viii, 389 (1910); [7] *idem*, viii, 381 (1910); [8] *idem*, 383, viii. (1910); [9] Jour. Am. Chem. Soc., xxxii, 1680 (1910); [10] Jour. Biol. Chem., viii, 391 (1910); [11] *idem*, viii, 392 (1910); [12] Jour. Am. Chem. Soc., xxxiii, 81 (1911); [13] Jour. Biol. Chem. (1911); [14] Jour. Am. Chem. Soc., xxxi, 116 (1909); [15] Jour. Am. Chem. Soc., xxxii, 1679 (1910).

With a recognition of the importance of a more thorough knowledge of the chemical nature of the organic matter of soils, the Division of Fertility Investigations of the Bureau of Soils has been carrying on a research dealing with this material largely by biochemical methods; methods which have heretofore been used in the isolation and identification of organic compounds from plant or animal tissues or other methods devised along similar lines.[1] The result of this work so far is that twenty definite organic compounds have been isolated from that portion of the soil organic matter included in the term humus. These compounds comprise eight classes: paraffin hydrocarbons, acids, alcohols, esters, carbohydrates, hexone bases, pyrimidine derivatives, and purin bases being represented. Some of these, such as purin bases, pyrimidine derivatives, and hexone bases, have been isolated by methods well-known and in common use by biochemists. Others for which no method existed or which from the nature of the material required special treatment, have been obtained by methods devised for the purpose but all founded on the ordinary technic of biochemical work.

The method by means of which the isolation of the substances from the organic matter of soil was accomplished may be briefly shown in the accompanying schematic representation (Table I), although for actual working details the individual journal articles must be consulted.

From the work so far accomplished it has been shown that the organic matter of soils is made up of a large number of organic compounds, a great majority of the classes of compounds found in plants and animals being represented.

The conclusion seems warranted that while this material is very complex and the character of only a portion of it is at present understood, the complexity is not so great, but that by the application of biochemical methods of research, the chemical nature of the whole of it may ultimately be established.

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[1] See especially Bulletins 53 and 74, Bureau of Soils, U. S. Department of Agriculture, for details in this connection.

NOTES ON THE HISTORY OF BALLOON PHOTOGRAPHY.

EDWARD DOLEZAL,

Extraordinary Professor in the Royal Imperial High School in Vienna.

(Abstracted and translated by Henry Leffmann from a lecture published in the 50th volume (1909–10) of the Publications of the Vienna Society for the Diffusion of Knowledge in Natural Sciences.)

THE well-known French writer, A. Davanne, for a long while the president of that highly distinguished society, the "Société Française de Photographie" in Paris said in an address: "The world will never forget that to France is due the invention of photography and the promulgation of its method."

In August, 1909, seven decades had elapsed since the French scientists, Arago and Gay Lussac, after a searching investigation of the process of painter Daguerre and cavalry officer Niepce, by which pictures could be taken by light, recommended the purchase of the rights thereto by the French government. The purchase was made and through the liberality of the government, Arago was able on August 29, 1839, to make known the methods at a public session of the Academy of Sciences.

Arago's foresight was sufficient to indicate to him the value of the method in connection with the preparation of maps and charts, but he did not foresee its use in connection with balloon work. The latter application originated with a Frenchman named Andraud, who in an essay,—"Une derniére annexe au Palais de l'Industrie," expressed some views on balloon photography, in which, indeed, he allowed his fancy to play in almost the style of Jules Verne. The merit of taking the first balloon photograph belongs to a Paris photographer and aeronaut, Nadar senior. His experiments showed, as was to be expected, that the photographic procedure of that day,—wet plates and prompt development,—involved serious difficulties. Nadar installed a dark room in the basket of the balloon in the form of a tent of orange stuff with black lining. It appears however, that the carbon disulphide in the gas affected his plates. He did not lose hope. At "Petit Bicêtre" a hamlet consisting

only of a dairy-farm, a tavern and small barracks, he prepared his plates, rose quickly to the height of about 80 metres in a captive balloon, returned and developed the pictures. Nadar having thus shown the practicability of such photography, was invited in 1859 by the Italian minister of war to test his method in connection with the war with Austria, but the results, especially at Solferino, did not meet expectations.

In spite of these failures, balloon photography found new disciples in Europe and in the new world. In 1860, King and Black made such photographs in the neighborhood of Boston, U. S.; an Italian, Negretti, at the instance of King Victor Emmanuel I, succeeded in taking pictures from a free-moving balloon, and in the American Civil War, Lowe obtained views which served as guides for important military operations.

Nadar anticipated great results from his experiments, took out many patents and also published articles, his views being occasionally fantastic. In 1868, he resumed his experiments in Paris, using a captive balloon furnished by Henry Giffard, with which he reached a height of 200 metres and took a picture showing the triumphal arch, and other important structures. This negative is still to be seen in the collection of the Conservatoire des Arts et Métiers in that city. It marks a material progress in the art.

No important results in balloon photography were reported during the Franco-Prussian War, and the subject seemed to be neglected until 1878 when the Paris photographer, Dagron, took it up with much energy and obtained, with a captive balloon, a striking picture of Paris on a negative 22 x 28 cm. (about 9 x 12 inches). Dagron used a basket dark-room as Nadar had done.

With the discovery of the dry-plate method by the English physician Maddox a new era began for balloon photography. Triboulet, an architect, and an enthusiastic promoter of meteorologic investigations, was the first to use the dry-plate in a free-moving balloon. On June 8, 1879 he ascended in the balloon Jovis from a hamlet near Paris, the photographic apparatus being fastened to the side of the basket. At a height of 500 metres above the Paris observatory, he took a panoramic picture, but scarcely had this been made when a cloudburst occurred that compelled him to descend although he had thrown out all available ballast. Unluckily, his balloon struck one of

the Notre-Dame towers and he subsequently came down in the Seine. As the balloon was an unusual visitor to the city, a zealous custom-officer followed it—on foot it seems—and when the balloonist reached the shore insisted upon a thorough search of all the packages and so in spite of the protests of the experimenter, the dark slide had to be opened and the picture was ruined.

In 1880, Desmaret succeeded in a free-moving balloon in taking pictures 21 x 27 cm. using a lens of 29 cm. focus and regulating the duration of exposure by electrical apparatus. He had also in his basket accurate barometers, and regulated the exposure according to the speed of the balloon. He used highly sensitive plates. Two of his negatives are to be seen in the Conservatoire des Arts et Métiers. In 1882, Shadbolt of England did good work in this field.

Attention now began to be directed to the construction of apparatus especially adapted to balloon photography, the methods heretofore followed having been merely the attaching of ordinary cameras to the basket. In 1881, Woodbury of England constructed a camera for automatic photography from a captive balloon but it was not a success. In 1884 Triboulet built an apparatus consisting of seven cameras so arranged that when suspended beneath the basket they formed an inverted arch and by an electrical connection the whole series could be snapped at once and thus a wide field photographed.

The evident advantage that such photography might give in war led all the active European nations to take up the subject now that good results seemed possible and Tissander, Ducom and Renard in France, Eleslade and Templar in England, von Tschudi, von Hagen and von Sigsfeld in Germany, Thiele and Uljanin in Russia, Ranza in Italy and Speltrini in Switzerland are among those who labored in developing the methods. Ranza invented a form of captive balloon specially adapted for photographic work and materially advanced the technic of the art. Speltrini was the first to cross the Alps in a balloon and he secured striking pictures of the mountain peaks.

Victor Silberer was the first to carry out balloon photography in Austria. In 1885 he took a picture of the Reichsbruecke in Vienna. Silberer also organized and conducted the first military school for aeronautics, and he carried the work to such a point that it became entirely suitable for strategic purposes.

FRANKLIN INSTITUTE

(*Proceedings of the Stated Meeting, held Wednesday, February 15, 1911.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 15, 1911.

PRESIDENT WALTON CLARK *in the Chair.*

Additions to membership since last report, 7.

The standing Committees for the year 1911–12 were announced.

The President called attention to the fact that Colonel George W. Goethals, U. S. A., Chief Engineer of the Isthmian Canal Commission, would address the Engineers' Club, on the "Panama Canal" this evening and that the members of the Institute are invited to attend.

On motion the invitation was accepted, the programme arranged for this meeting was postponed, and the members adjourned to the Engineers' Club.

R. B. OWENS,
Secretary.

STANDING COMMITTEES 1911.

Of the Board of Managers.

INSTRUCTION.

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G. A. Hoadley,
E. V. McCaffrey,
Charles Day,
J. S. Rogers,
R. B. Owens, *ex officio.*

STOCKS AND FINANCE.

Walton Forstall, *Chairman,*
R. W. Meirs,
E. H. Sanborn,
A. C. Harrison,
Treasurer of the Institute.

EXHIBITIONS.

John Birkinbine, *Chairman,*
James Dodge,
E. H. Sanborn,
W. C. L. Eglin,
C. A. Hexamer.

ELECTIONS AND RESIGNATIONS OF MEMBERS.

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Otto C. Wolf,
Walter Wood,
Alex. P. Robinson,
Alexander Krumbhaar.

PUBLICATIONS.

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SECTIONAL ARRANGEMENTS.

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Of the Institute.

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Richard Gilpin,
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Carl Hering,
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Henry Leffmann,
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George F. Stradling,
John C. Trautwine, Jr.

MEETINGS.

G. S. Barrows,
James Christie,
G. H. Clamer,
Kern Dodge,
Lewis M. Haupt,
H. A. Hornor,
J. Y. McConnell,
James S. Rogers.
Coleman Sellers,
W. J. Williams,

MUSEUM.

A. A. Blair,
R. H. Bradbury,
Charles Day,
E. Goldsmith,
W. H. Greene,
Geo. A. Hoadley,
E. V. d'Invilliers,
Harry F. Keller,
A. E. Outerbridge,
Wm. H. Thorne.

REPORT OF THE COMMITTEE ON STOCKS AND FINANCE FOR THE YEAR 1910.

To the Board of Managers:

Financial Statement. October 1, 1909 to September 30, 1910.

PROPERTY AND FUNDS.

Building and land, 13-17 S. Seventh Street		$44,000.00	
Library		100,000.00	
Apparatus, collections and models		5,022.49	$149,022.49
	Principal	Unexpended Income	
Funds held by Board of Trustees	$93,310.28	$770.25	
Funds held by Board of Managers	23,478.50	767.77	
Franklin Fund	341,967.42		
Elliott-Cresson Medal Fund	1,000.00	3,156.20	
Franklin Fund and Building Committee	4,689.97		
Total funds	$434,446.17	$4,694.22	$439,140.39
Grand total			$588,162.88

LIABILITIES.

Certificates of Stock	$31,210.00
Mortgage on Institute Building (held by Trustees as investment for Funds)	3,575.00
Bills payable	20,250.00
Life memberships	3,835.00
Accounts payable	3,432.69
Unearned income	658.96
Grand total	$62,961.65

INCOME AND EXPENSES APPLICABLE TO YEAR ENDING SEPTEMBER 30.

INCOME.

Dues	$8,791.67
Initiation fees	90.00
General endowment fund	2,223.32
Estate of John Turner	104.98
Estate of Robert Wright	2,097.24
Miscellaneous	17.97
Membership badges	4.00
Instruction: Machine design	309.06
Publications: Subscriptions and sales	1,665.74
Publications: Advertising	2,844.21
Total	$18,148.19

EXPENSES.

Building:	Wages	$843.30	
	Repairs and maintenance	151.37	
	Heat, light and power	717.15	
	Taxes, water rent and insurance	472.79	
	Miscellaneous supplies and expenses	498.89	$2,683.50
Elections and Resignations			129.45
Instruction:	Drawing School	$36.60	
	Naval Architecture	30.36	
	Popular Lectures	652.54	719.50
Library:	Salaries	$2130.75	
	Books and Periodicals	1525.38	
	Binding	870.25	
	Miscellaneous expenses	299.46	4,825.84
Meetings			225.93
Office and General:	Salaries	$5270.27	
	Office expense	245.26	
	General expense	1101.65	6,617.18
Publications:	Printing	$3251.31	
	Reprints	192.45	
	Illustrations	286.12	
	Miscellaneous Expense	219.44	3,949.32
Science and Arts			222.81
Sections			445.64
Interest and Discount			799.59
Frederic Graff Rebuilding			120.29
Interest paid John T. Kille on donation to General Endowment Fund			200.00
Total			$20,939.05
Net expense			$ 2,790.86

During the year, the General Endowment Fund has been increased by $280.16, through bequest from the Estate of James Neumann. The building Fund of the Board of Trustees has been merged into the Franklin Institute Building Fund. Of the Elizabeth M. Graff Fund, $4000 has been devoted to renovating the Institute building. The Franklin Institute Building Fund has been increased over $10,000, through interest accretions. Certificates of Stock, First Class, have decreased by $4310, chiefly due to donations of stock in return for memberships. The mortgage on the Institute building has been reduced by $750. $2050 of notes given in payment of deficit subscriptions have been cancelled by holders.

The excess of expenses over income for the year was $2790.86. This was entirely due to expenses required to broaden the influence of the Institute, and to place it once more in a position where an increased membership will furnish an income adequate to its needs.

Respectfully submitted,

WALTON FORSTALL,
Chairman.

PHILADELPHIA, PA., January 11, 1911.

REPORT OF COMMITTEE ON ELECTIONS AND RESIGNATIONS OF MEMBERS.

To the Board of Managers:

During the Fiscal Year (October, 1909, to September, 1910, incl.), there were elected to membership, 54 resident members, 19 non-resident members, 5 associate members and 4 life members.

During the same period, there were resignations from 29 resident members, and 17 non-resident members, and deaths were recorded of 3 resident members, 2 non-resident members, 2 life members, 1 second-class stock member and 1 honorary member.

Respectfully submitted,

W. C. L. EGLIN,
Chairman.

PHILADELPHIA, PA., January 11, 1911.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of the Stated Meeting, held Wednesday, February 1, 1911.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 1, 1911

MR. THOMAS SPENCER *in the Chair.*

Dr. George A. Hoadley was elected chairman for the year 1911-12.

In the absence of a quorum the reports for final action were not considered.

The following reports were presented for first reading:

No. 2461.—Shore's Scleroscope.

No. 2494.—Seley's Steel in the use of freight car construction (Advisory).

Adopted.

R. B. OWENS,
Secretary.

SECTIONS.

Section of Physics and Chemistry.—The stated meeting of the Section was held on Thursday, January 26, 1911, in the Hall of the Institute, at 8 P.M., with Dr. Robert H. Bradbury, President of the Section in the Chair.

One hundred and twenty-five members were present.

The minutes of the previous meeting were approved as read.

Dr. Harry F. Keller, Professor of Chemistry and head of the Department of Science in the Central High School of Philadelphia, delivered a lecture upon the "Use of Lantern Slides in the Teaching of Chemistry." He emphasized the value of lantern slides as an adjunct in the teaching of chemistry, but strongly recommended that pictures of an experiment should supplement but never replace the experiment itself in a lecture upon general chemistry.

Dr. Keller described the large and valuable collection of slides bearing upon chemistry which he has collected in the Central High School. This collection falls into four grand divisions: historical, general, industrial and special.

The historical portion consists of portraits of famous chemists, their apparatus and laboratories; the general division comprises pictures of apparatus and experiments relating to general chemistry, the industrial slides illustrate the various applications of chemistry in the arts. The special division contains slides prepared especially for certain lectures such as Chemists' Workshops Old and New, Illumination, etc. The collection as a whole is one of the best in America, and the historical portion is without a peer upon this continent.

The lecture was illustrated with the gems of the collection. A vote of thanks was tendered Dr. Keller, and the meeting adjournd.

JOSEPH S. HEPBURN,

Secretary.

Electrical Section.—A meeting of the Section was held on Thursday, February 2, 1911, at 8 P.M.

Mr. Thomas Spencer in the Chair. Fifty members and visitors present.

After the reading and approval of the minutes of the previous meeting the Chairman introduced Mr. F. G. Vaughen, of the General Electric Company, Schenectady, New York, who read a paper on "Prepayment Electric Meters." The speaker outlined the history of coin-controlled devices and referred especially to the design, construction, and requirements of a good Prepayment Electric Meter. The subject was fully illustrated by lantern slides. A lengthy discussion followed the reading of the paper in which Mr. Snook, Mr. Green, Dr. Owens, the Chairman and others took part. On motion a vote of thanks was tendered the speaker and his paper was referred to the Committee on Publications. Adjourned.

R. B. OWENS,

Acting Secretary.

Mining and Metallurgical Section.—A meeting of the Section was held on Thursday evening, February 9, at 8 o'clock. In the absence of the regular officers of the Section the Librarian of the Institute introduced Dr. Edgar T. Wherry, of Lehigh University, South Bethlehem, Pa., who presented a report on the "Eleventh International Geological Congress held at Stockholm, Sweden, during the Summer of 1910."

Dr. Wherry represented the Institute at the deliberations of this Congress and his report outlined the work of the organization and the various geological excursions which preceded and followed the meetings. He gave an interesting account of the metals, mines and mineral deposits of Sweden and Norway.

The subject was fully illustrated by lantern slides made from original photographs of many subjects relating directly or indirectly to the Congress and to the metallurgical work and mines of Scandinavia.

Section of Physics and Chemistry.—The Stated Meeting of the Section was held in the Hall of the Institute on Thursday, February 16, 1911, at 8 P.M., with Dr. R. B. Owens in the Chair. Forty-two members and visitors were present.

The minutes of the previous meeting were read and approved. Mr. L. S. Dow, of the H. J. Heinz Company, Pittsburg, Pa., delivered an address upon Modern Commercial Food Manufacturing. The various methods were discussed which have been used from prehistoric times for the preservation of foodstuffs, including smoking, salting, sterilization and the use of chemical antiferments. The statement was made that by the use of cleanly methods of preparation, followed by sterilization, perishable foodstuffs may be preserved without the use of chemicals. The lecture was illustrated with lantern slides depicting the growing and preserving of vegetables, the preparation of olive oil and the manufacture of cider vinegar. The paper was referred for publication, a vote of thanks was given to Mr. Dow, and the meeting adjourned.

JOSEPH S. HEPBURN,
Secretary.

MEMBERSHIP NOTES.

Elections to Membership.

RESIDENT.

MR. J. A. P. CRISFIELD, 1405 Arch Street, Philadelphia, Pa.
MR. H. A. HORNOR, New York Ship Building Co., Camden, N. J.
MR. M. M. PRICE, Babcock & Wilcox Co., 1010 North American Building, Philadelphia.
MR. GEORGE L. THOMPSON, General Electric Company, Witherspoon Building, Philadelphia.

NON-RESIDENT.

DR. CLAYTON H. SHARP, Electrical Testing Laboratories, 80th St. and East End Ave., New York City.
MR. F. G. VAUGHEN, General Electric Co., Schenectady, N. Y.

ASSOCIATE.

MR. JOSEPH SHALLCROSS WEBB, Swarthmore College, Swarthmore, Pa.

Changes of Address.

MR. W. H. GARTLEY, P. O. Box 1902, Philadelphia.
MR. D. E. MAXFIELD, 6 West Oak Ave., Moorestown, N. J.
HON. EDWARD MORRELL, Morris Building, 1421 Chestnut Street, Phila.
MR. F. R. PLEASONTON, P. O. Box 102, Steelton, Pa.
MR. MARRIOTT C. SMYTH, 1700 Morris Building, Philadelphia.
MR. EDWIN D. TUCKER, 39-41 West Twenty-third Street, New York City.

NECROLOGY.

Mr. R. Winder Johnson, 209 S. Third Street, Philadelphia.
Mrs. Clara E. Stewart, The Gladstone, Eleventh and Pine Sts., Philadelphia.

LIBRARY NOTES.

Purchases.

American Civil Engineers' Pocket-Book.
PETIT, R.—How to Build an Aeroplane.
BERGET, A.—The Conquest of the Air.
MOOREHEAD, W. K.—The Stone Age in North America.
POYNTING, J. H.—The Pressure of Light.
SMILES, S.—The Relations Between Chemical Constitution and Some Physical Properties.
JOHNSON, G. L.—Photographic Optics and Colour Photography.
A History of the Cavendish Laboratory, 1871-1910.
PLANCK, M.—Das Prinzip der Erhaltung der Energie.
WHITAKER, J.—Almanac for 1911.
SPITTA, E. J.—Microscopy.
British Journal Photographic Almanac for 1911.
SEATON, A. E.—The Screw-Propeller.
BREWER, R. W. A.—The Art of Aviation.
Nelson's Perpetual Loose-leaf Encyclopædia, 12 vols.
CAJORI, F.—A History of the Logarithmic Slide-rule.
HALL, H. R.—Governors and Governing Mechanism.
PIERCE, G. W.—Principles of Wireless Telegraphy.

Gifts.

Iowa Railroad Commissioners. Thirty-second Annual Report for 1909. Des Moines, 1910. (From the Commission.)

Pennsylvania Topographic and Geologic Survey Commission Report No. 3. Harrisburg, 1910. (From the State Librarian.)

Mysore Meteorological Department. Report on Rain-fall Registration for 1909. Bangalore, 1910. (From the Department.)

American Institute of Electrical Engineers. Yearbook for 1911. New York, 1911. (From the Institute.)

Iron and Steel Institute Journal 1910, Part 2. London, 1910. (From the Institute.)

Yale University Catalogue for 1910–1911. New Haven, 1910. (From the University.)

Oklahoma Geological Survey. Bulletin No. 6. Norman, 1910. (From the Survey.)

American Mining Congress. Report of the Proceedings of the Thirteenth Annual Session held at Los Angeles, California, September 26 to October, 1 1910. Denver, 1910. (From the Congress.)

Interstate Commerce Commission. Twenty-second Annual Report on the Statistics of Railways in the United States for the year ending June 30, 1909. Washington, 1910. (From the Commission.)

United States Naval Observatory, Publications, vol. 4. Parts 1 to 4. Washington, 1906. (From Hon. J. Hampton Moore.)

Manchester Municipal School of Technology Journal, volume 3 of 1909. Manchester, 1910. (From the Education Committee.)

Great Britain Labour Department. Fourth Abstract of Foreign Labour Statistics. London, 1911. (From the Department.)

Boston Transit Commission. Sixteenth Annual Report, 1910. Boston, 1910. (From the Commission.)

Canadian Mining Institute Journal, vol. 13, 1910. Montreal, 1911. (From the Institute.)

New York State Education Department. Annual Report for 1910, vols. 2 and 3. Albany, 1910. (From the New York State Library.)

Philadelphia—A Periodical, vols. 1, 2, 3—1909–1910. Philadelphia, 1910. (From the City of Philadelphia.)

Wisconsin—Report of the State Forester for 1909, 1910. Madison, 1910. (From the State Board of Forestry.)

Liverpool Literary and Philosophical Society—Proceedings No. 61. Liverpool, 1910. (From the Society.)

Tasmania—Geological Survey, Bulletin No. 8, with Geological Maps and Mine Plans. Hobart, 1910. (From the Survey.)

London Meteorological Office—Meteorological Observations at Stations of the Second Order for 1907. London, 1910. (From the Office.)

Rendiconto delle Sessioni della R. Accademia delle Scienze dell'Institutio di Bologna. Classe di Scienze Fisiche, Nuova Serie, vol. xiii, 1908–1909. Bologna, 1909. (From the Institute.)

Memorie della R. Accademia delle Scienze dell'Instituto di Bologna. Classe di Scienze Fisiche, Serie vi, Tomo vi, 1908–1909. Bologna, 1909. (From the Institute.)

Atti del R. Instituto d' Incoraggiamento di Napoli. Serie Sesta, 1909, vol. 61. Napoli, 1910. (From the Institute.)

Michigan State Board of Agriculture, Forty-ninth Annual Report of the Secretary, July 1909 to June, 1910. Lansing, 1910. (From the State Board.)

India Weather Review. Annual Summary, 1909. Simla, 1910. (From the Meteorological Department.)

Lake Superior Mining Institute—Proceedings, vol. 15, 1910. Ishpeming, 1910. (From the Institute.)

Congressional Directory, 61st Congress, 3rd Session, 1st and 2nd Editions, December, 1910, and January, 1911. Washington, D. C., 1910–1911. (From the Superintendent of Documents.)

Pennsylvania Department of Forestry, Report for the Years 1908–1909. Harrisburg, 1910. (From the Department.)

Smithsonian Institution. Report for 1909. Washington, 1910. (From the Institution.)

BOOK NOTICE.

QUESTIONED DOCUMENTS. A Study of Questioned Documents with an Outline of Methods by which the Facts May Be Discovered and Shown. By Albert S. Osborn, Examiner of Questioned Documents, with an introduction by Professor John H. Wigmore, author of "Wigmore on Evidence." 8vo, cloth, xxiv + 501 pages with 200 illustrations. Price, $5.25. Lawyers' Coöperative Publishing Company, Rochester, N. Y., 1910.

The paramount importance of establishing the genuineness or fraudulence of documentary records is indisputable. Handwriting is one of the few modes of permanently recording a transaction along with the imprint of the personality of the maker thereof. It is a matter of common observation that a person's signature varies comparatively little even after a considerable lapse of time. It is not so evident, but becomes so on close study, that there are certain characteristics unconsciously produced which are well-nigh non-concealable and that positively identify this origin.

Much effort in recent times has been devoted to a study of these characteristics and to the other features as well that govern the conditions and form of written documents. The results of such researches have been of inestimable value particularly in cases of legal inquiry. The duty of an expert witness entrusted with the investigation of a disputed document upon which important issues may depend is an extremely responsible one and he must be not only fully qualified as to scientific attainment but his mode of procedure should be reduced to a code of practice that will with certainty lead to accurate and fully verified results.

Mr. Osborn's work is a treatise developing the subject in a manner conducive to that end. The expert employing his methods will be prepared, in presenting his views, to sustain them with adequate demonstrations. The best mode of handling documents, their peculiarities, how made apparent and identified as well as a multiplicity of other features disclosed by chemical and physical methods are described at great length. Well executed reproductions of specimens of writing in natural size with photographic enlargements show clearly the utility of the photographic camera in such investigations. The illustrations of the apparatus employed in position for use add much to the value of the work for any one studying the subject with a view to practically applying it.

Many of the methods and processes have been described by a late member of the Franklin Institute, Dr. Persifor Frazer, who was deeply interested in the study of documents and published the results of his labors in that direction under the name "Bibliotics" in 1901. The extensive bibliography at the end of the volume indicates that many others have also worked in the same field, but the lack of fundamental originality does not detract from the decided merit of a book presenting an illuminating and unusually well illustrated account of the most efficient means of applying what has been accomplished in the study of questioned documents.

PUBLICATIONS RECEIVED.

A course in Qualitative Chemical Analysis. By Charles Baskerville, Ph.D., F.C.S., Professor in the Department of Chemistry, College of the City of New York, and Louis J. Curtman, Ph.D., Instructor in the Department of Chemistry, College of the City of New York. 200 pages, 8vo. New York: Macmillan Co., 1910. Price in cloth, $1.40.

Motion Study—A Method for Increasing the Efficiency of the Workman. By Frank B. Gilbreth, Member of the American Society of Mechanical Engineers. With an introduction by Robert Thurston Kent, Editor of Industrial Engineering. 116 pages, 12vo. New York: Van Nostrand Co., 1911. Price, in cloth, $2.00.

U. S. Department of Interior. Bureau of Mines, Bulletin 4. Features of Producer-gas Power-plant Development in Europe. By R. H. Fernald. 27 pages, plates, 8vo. Washington, Government Printing Office, 1911.

U. S. Department of Interior. Bureau of Mines. Miner's Circular 2. Permissible Explosives Tested Prior to January 1, 1911, and Precautions to be Taken in Their Use. By Clarence Hall. 12 pages, 8vo. Washington, Government Printing Office, 1911.

Library of Congress. Publications of the Library Issued Since 1897. 45 pages, 12mo. Washington, Government Printing Office, 1911.

University of Missouri School of Mines and Metallurgy, Bulletin, December, 1911. 39 pages, 8vo. Rolla, Missouri, n.d.

Hygiene, Offizielle monatsschrift der Internationalen Hygiene-Ausstellung, No. 1, January, 1911. 16 pages, illustrations, 4to. Dresden, 1911.

Wisconsin Engineer. February, 1911. Vol. 15, No. 5. Madison, Wisconsin Engineering Journal Association, 1911.

Allen's Commercial Organic Analysis. A treatise on the properties, modes of assaying, and proximate analytical examination of the various organic chemicals and products employed in the arts, manufacture, medicine, etc., with concise methods for the detection and estimation of their impurities, adulterations, and products of decomposition. Vol. 4. Resins, india-rubber, rubber substitutes and gutta-percha, hydrocarbons of essential oils, ketones of essential oils, volatile or essential oils, special characters of essential oils, tables of essential oils by the editors and the following contributors: M. Bennett Blackler, E. W. Lewis, T. Martin Lowry, Ernest C. Parry, Henry Leffmann, Charles H. LaWall. Fourth edition, entirely rewritten. Edited by W. A. Davis, B.Sc., and Samuel S. Sadtler, S.B. 466 pages, illustrations, 8vo. Philadelphia, P. Blakiston's Son & Co., 1911. Price, cloth, $5.00.

CURRENT TOPICS

Production of Spelter in 1910.—*Gratifying Growth of the Zinc Industry.*—The annual preliminary statement just issued by the United States Geological Survey shows that so far as production and consumption are concerned the spelter industry of the country enjoyed a year of continued normal growth. The total production of spelter in the United States in 1910 broke all records; the production from domestic sources alone exceeded the total production for any previous year in the history of the industry and exceeded the domestic production for any other year by 20,000 tons. Coupled with this increase in production there was a decrease in imports and at the same time exports were more than quadrupled.

The following figures have been compiled without change by C. E. Siebenthal, of the Geological Survey, from reports furnished by all operating smelters of zinc ores, showing their output for the first eleven months of the year and their estimated production for December. Figures showing the imports and exports for eleven months were obtained from the Bureau of Statistics and to these figures estimates for December have been added.

Production.—The production of primary spelter from domestic ore in 1910 is estimated at 250,052 short tons and from foreign ore at 17,371 tons, a total of 267,423 tons, worth, at the average price, $28,881,684, as compared to a total of 255,760 tons in 1909, made up of 230,225 tons of domestic origin and 25,535 tons of foreign origin. The production of spelter from both domestic and foreign ores, apportioned according to the States in which the ores were smelted, was approximately as follows: Illinois, 73,373 tons in 1910 and 67,653 tons in 1909; Kansas, 105,659 tons in 1910 and 103,299 tons in 1909; Oklahoma, 34,762 tons in 1910 and 28,782 tons in 1909; all other States, 53,629 tons in 1910 and 56,026 tons in 1909. The total production of spelter is equivalent to the output of 61,700 average retorts operating continuousuly through the year, or about 70 per cent. of the maximum capacity of the smelting plants in operation for some part of 1910.

Imports and Exports.—The imports of zinc ore fell off over 25 per cent. They were approximately 85,084 short tons, containing about 83,000,000 pounds of zinc and worth, as invoiced, about $888,000; 116,269 tons of zinc ore were imported in 1909. The figures for 1910 do not include 10,431 short tons of lead ore from South America, containing 2,645,111 pounds of zinc, an average of less than 13 per cent., all of which was lost in smelting the lead and thus does not properly enter into the figures of im-

ports of zinc. Of the zinc ore imported, 80,309 tons, or 90 per cent., came from Mexico, as compared with 106,245 tons imported from Mexico in 1909. The exports of zinc ore for the first eleven months of 1910 were 17,558 short tons, valued at $570,510, as compared with 12,455 tons in 1909.

Imports of spelter were decreased over half, being estimated at 3339 short tons, valued at $282,653, as compared with 9670 tons in 1909. Exports of domestic spelter increased over 50 per cent., being estimated at 3953 short tons, valued at $424,172, as compared with 2566 tons in 1909. The establishment of zinc smelting in bond increased the exports of foreign zinc from their previously insignificant proportions to approximately 5029 short tons, valued at $196,250, in 1910. During the first nine months of the year there were also exported, under drawback, articles manufactured from 2717 tons of foreign spelter on which duty had been paid. The exports of zinc dross amounted to 4675 short tons, valued at $377,000, as compared with 7069 tons in 1909.

Consumption.—The apparent domestic consumption of spelter in 1910 may be computed as follows: The sum of stock on hand at smelters at the beginning of the year, 11,167 tons, plus the imports, 3339 tons, and the production, 267,423 tons, gives the total available supply, 281,929 tons. From this are to be subtracted the exports of domestic spelter, 3953 tons; the exports of foreign spelter, 5029 tons; the exports under drawback, 2717 tons; and the stock on hand at smelters at the close of the year (to be exact, on hand December 15), 20,170 tons, a total of 31,869 tons, leaving a balance of 250,060 tons as the apparent domestic consumption, almost exactly the production from domestic ores. This calculation takes no account of the stocks of spelter held by dealers or consumers. On comparing the apparent consumption in 1910 with the 271,274 tons in 1909 the 215,401 tons in 1908, and the 228,524 tons in 1907, it is seen to be about normal, indicating that stocks other than those at smelters have at least not greatly increased during the year.

Prices.—Spelter opened at St. Louis in January at 6.05 to 6.075 cents a pound, the highest price of the year, and declined until the middle of June, when the minimum for the year was reached at 4.925 cents a pound. During the latter part of the year the price made a considerable recovery, reaching 5.90 cents in the middle of November, but afterward a decline set in and the year closed with spelter around 5.3 cents a pound. The average St. Louis price of prime western spelter was the same as for 1909—5.4 cents a pound.

The Inspection of Castings. J. A. GEARHEART. (*Iron Age*, lxxxvi, 1142.)—A detailed description of an Inspector's duties and how they should be carried out. This article will be of interest to manufacturers, users, and inspectors of castings.

The Magnetic Properties of Iron and its Alloys in Intense Fields. R. A. HADFIELD AND B. HOPKINSON. (*Engineering, London,* xc, 835.)—An investigation which appears likely in the future to furnish data and a method of experiment which will be of assistance in research work on the physical constitution of iron and iron alloys is being carried out by Sir Robert A. Hadfield and Professor Bertram Hopkinson. The investigation is concerned with the magnetic properties of these materials in intense fields, and there is a singular appropriateness in the fact that the actual magnetic testing is being carried out by Professor Hopkinson at Cambridge, since the investigation is, in a measure, an extension and development of Ewing's pioneer work on magnetism. Some account of the results which have been so far obtained was presented in a paper by Sir Robert Hadfield and Professor Hopkinson, read before the Institution of Electrical Engineers.

The investigation was undertaken to determine the relation between the magnetizing force and the flux density in the H and B, of magnetic materials, in intense fields. In the moderate fields employed in practice the relation between these two quantities is complicated and dependent on many variables, but in intense fields this relation assumes a very simple form. According to Ewing's molecular theory of magnetism it may be supposed that in moderate fields the relation between H and B is a function of the interactions between the individual molecules, and that the molecular configuration which results in such fields is dependent largely on external conditions and on the previous history of a material; but in intense fields it may be assumed that the molecular configuration taken up is determined only by the magnetizing force, as this is strong enough to entirely swamp the effect of interactions between the molecules, so that they all set themselves in the direction of the force. On this supposition the relation between B and H, in intense fields, becomes:

$$B = H + 4\pi I,$$

where I is the sum of the magnetic moments of the molecular magnets contained in unit volume of the material, and certain experiments of Ewing, Low, and Du Bois show that in iron, nickel, cobalt, and some alloys, B does actually exceed H by nearly a constant quantity when H lies between 2000 and 25,000 c. g. s. units. It will be clear that an assumption that the quantity $4\pi I$ in the above expression is a constant for high value of H involves the second assumption that the moment of individual molecular magnets is not affected by the external magnetic forces to which they are subjected, and while the experiments of Ewing, Low and Du Bois do not establish the constancy of this quantity, they at least give strong grounds for supposing that in certain materials the mutual interactions between the molecules are almost completely overpowered by a magnetizing force greater than 2000 c. g. s. units.

If this assumption is correct, the saturation value of $4\pi I$,—*i.e.*, the constant quantity by which B exceeds H in fields above a certain inensity,—is established as a definite measurable physical constant for any magnetic material. This quantity may conveniently be referred to as the specific magnetism.

The experiments of Sir Robert Hadfield and Professor Hopkinson were carried out on a series of alloys of iron with carbon and other materials with the idea that not only might some deductions be drawn as to the magnetic properties of the materials, but also as to their constitution. The great advantage of the magnetic examination of such materials in intense fields lies in the fact that the saturation value of $4\pi I$ in a material consisting of a mixture of substances is dependent only on the relative proportions and the magnetic properties of the various substances separately, and not on their arrangement in the mass. Most steels consist of such a mixture of substances, and any examination of their magnetic properties in fields of ordinary intensity is so complicated by molecular interactions determined by the microstructure that it is hopeless to look for any simple relation between their magnetic properties and their composition. In intense fields, however, troubles disappear owing to the swamping of the molecular interactions, so that the magnetic properties of an alloy become a measure of its composition. The many experiments which have been so far carried out definitely establish a saturation intensity of magnetization for all the alloys examined, and at the same time show that the method is capable of being used in an examination of the actual physical constitution of alloys, although the work has not yet been carried beyond a preliminary stage.

The measurements were carried out on small testpieces ⅛ in. in diameter, and in most cases ¼ in. long, which were placed between the poles of an electro-magnet and surrounded by a small test-coil connected to a ballistic galvanometer. The tests were carried out by reversing the current passing through the coils of the electro-magnet and observing the galvanometer deflection. The electro-magnet had conical or flat pole-faces depending on the field intensity which was being used, and various corrections were made to allow for the distortion of the field due to the presence of the testpiece. Field intensities up to 25,000 c. g. s. units were employed. In most cases saturation was reached in a field of 5000 units, but with a few materials there was a small increase between 5000 and 25,000 units. In all cases, however, the form of the curve connecting I and H left no doubt as to the existence of a saturation value of $4\pi I$; while in addition all the materials behaved as though they consisted of a mixture of magnetic substances with non-magnetic substances having a permeability of about unity. None of the alloys which were examined had a higher specific magnetism than pure iron. These facts are, of course, in accordance with the theory that in intense fields the molecular inter-

actions are entirely swamped, so that the value of the specific magnetism becomes a measure of the amout of magnetic material present in a body, and so of its constitution.

Measurements which were carried out on a specimen of annealed iron-carbon steel, in which other elements were present in but small proportions, showed that the specific magnetism of the specimen was less than that of pure iron by a percentage equal to six times the percentage of carbon present. If this alloy be regarded as a mixture of pure iron with carbide of iron Fe_3C, the proportion of carbide of iron would be 15.5 times the proportion of carbon, from which it follows, assuming that the two constituents are mechanically mixed, that the specific magnetism of carbide of iron is about two-thirds that of pure iron. A series of measurements were carried out with iron-carbon steels, which showed that when less than ½ per cent. of other substances were present, the effect of adding carbon was to reduce the magnetism by an amount proportional to the amount of carbon, the reduction being about six times the amount of carbon. Impurities present tended to mask the effect of the carbon to some extent, but a diagrammatic plotting of the reduction of specific magnetism against the proportion of carbon gave a straight-line curve with sufficient accuracy to suggest that the method might be used for determining the amount of combined carbon in a steel. Some of these iron-carbon steels were also examined after quenching from a high temperature. In general the effect of this was to reduce the specific magnetism but the results obtained were somewhat inconsistent. For instance, three samples were cut from a lump of white Swedish iron which had been quenched when molten, and the specific magnetism in percentages of that of pure iron proved to be, for the three specimens, 58.5, 64, and 72. These indefinite results must, of course, be attributed to the somewhat uncertain character of the quenching process. A somewhat similar result to the above was found with two samples of a silicon-manganese steel, which were quenched from 1200°; in one case the specific magnetism was found to be 62 per cent. of that of pure iron, and in the other only 20 per cent. Three samples of the same material, however, quenched from 1050° had a mean specific magnetism of 87.8 per cent. that of pure iron, which differs but little from 88.6 per cent., which is the mean of two annealed specimens. It is suggested that the difference in the two pieces quenched from 1200° may be explained by difference in the rate of cooling, as one piece was larger than the other, while the results obtained with the samples quenched from 1050° may have been due to the formation of cementite, which would occur at about 1100° as it is possible that the effect of quenching may depend upon whether free cementite is present or not.

The total number of samples of various alloys which were examined was very large, and it is not possible to give the results

in any detail in this article. In general, it may be said, however, that silicon appeared to act as an inactive diluent, and that some of the silicon-iron alloys were very soft magnetically, suggesting that silicon has the effect of reducing the interaction of the iron molecules. In some few cases silicon appeared to neutralize the effect of the carbon to some extent. Aluminum acted generally in a somewhat similar manner to silicon. The results obtained with iron-manganese alloys were very variable, and the authors were unable to find any simple relations between the proportion of manganese and the corresponding reduction in specific magnetism; they suggest that the effect of manganese may have been masked by that of some unknown variable, such as the temperatures to which the alloys may have been subjected during rolling or forging. The effect of heat-treatment on these alloys was exhibited by a sample containing 1.3 per cent. of carbon and 8.7 per cent. of manganese. As forged, this material had a value of B equal to 747 in a field of 240, while when annealed it had a value of 1985 in the same field, and when oil-hardened a value of 733. This shows that the cooling in air after forging had all the effects of oil-cooling, and suggests that such cooling, which, in the case of an iron-carbon alloy, has not much effect, is rapid enough in the case of an iron-manganese alloy to give the effect of quenching. The results obtained with iron-nickel alloys were also inconclusive, and they are now undergoing further investigation. This series, however, contained with iron-nickel alloys were also inconclusive, and they are greater than that of its elements taken separately. This was an alloy containing 11.4 per cent. of nickel, whose specific magnetism when saturated was 96 per cent. of that of pure iron. The alloy contained 87 per cent. of iron, and as the 11.4 per cent. of nickel is magnetically equivalent to about 3.5 per cent. of pure iron, the total specific magnetism of the constituents taken separately is only 90.5 per cent. as compared with the 96 per cent. given in the alloy. It will be clear that the investigation recorded in the paper is likely to be of much importance, and that although the results obtained so far rather indicate a new road for research than travel very far along it, the work forms an important contribution to the methods of research into the constitution of the iron alloys.

The Density of Radium Emanation. SIR WM. RAMSAY and R. W. GRAY. (*Comptes rendus*, cli, 126.)—The density of the radium emanation was approximately determined by weighing, on a specially designed micro-balance, a known volume of emanation calculated on the assumption that the amount of emanation in radioactive equilibrium with 1 Gm. of radium is 0.601 cubic mm. The mean value of five determinations gave 220 as the molecular weight: the highest was 227 and the lowest 216. The name of "Niton" is proposed for radium emanation.

Diffusion Phenomena of the Alums. C. L. PARSONS and W. W. EVANS. (*J. Amer. Chem. Soc.*, xxxii, 1378.)—When dissolved in water alums decompose into simple sulphates which may be separated by diffusion. The alums examined were ammonium-chromium, potassium-chromium, ammonium-aluminum, potassium-aluminum and ammonium-ferric alums. It was found that the separation by diffusion was more readily effected with the chrome alums than with the aluminum alums.

A New Remedy for Burns. ANON. (*La Nature*, No. 1959, 13.)—This is simply a lukewarm yeast poultice; either the dry yeast of grain or the wet yeast of breweries. The poultice is applied to the burns as quickly as possible. The pain subsides quickly and healing is remarkably hastened. From the recent work of Fernbach it appears that the cellules of the yeast can absorb the bacterial poisons.

Deciphering Writing on Burned Paper. ANON. (*La Nature*, No. 1759, 13.)—This is a most interesting problem either from the legal point of view, or from that of examining historical or other documents. The ashes of a large number of papers have been studied, and the traces left by the ashes of different inks or pencils. All trace of writing made with an ink composed of organic coloring matter or of lamp-black, *e.g.*, blue, red, violet and printing inks disappears on incineration; while inks composed from an iron salt, such as are generally used in Europe, leave a red-brown residue of ferric oxide. In this case the traces of writing become quite visible in the ashes of completely burned paper, and interesting documents, which were accidentally, or intentionally consumed, have been thus reproduced.

The Daily Motion of the Top of the Eiffel Tower. R. M. BOURGEOIS. (*Moniteur scientifique*, xxiv, 764.)—The Eiffel tower moves perceptibly daily under the influence of the heat of the sun. The extreme daily variation of the tip of the lightning conductor is the same as in 1896, and varies according to the atmospheric conditions from 3 to 17 cm. The mean position of the lightning conductor with reference to a fixed point has not sensibly varied from 1896 to 1908. The change of direction of the motion with the seasons confirms the fact, that the daily displacement of the top of the tower is certainly due to the sun.

Dielectric Behavior of Melted Vaseline. L. MALCLÈS. (*Comptes rendus*, cli, 63.)—A condenser made with a cell of insulating material, in which the vaseline is placed, is connected with one pair of quadrants of an electrometer and balanced against an adjustable condenser. The condensers are charged and a balance adjusted, and any after-effect is shown by a deflection of the electro-

meter needle. With vaseline in the ordinary semi-fluid state there is no after-effect, indicating that in this state vaseline is a perfect insulator, with a dielectric constant 1.97. When the cell between the condensers is filled with liquid vaseline and the vaseline allowed to cool and solidify, anamolous effects are observed, which the author explains by assuming that vaseline acts as a medium containing free ions, whose mobility is zero in the semi-fluid state but observable in the liquid state.

The Law of the Variation of the Coefficient of Specific Magnetization of the Elements by Heat. KOTARO HONDA. (*Mon. Sci.*, xxiv, 767.)—The effect of a rise in temperature on the coefficient of magnetization of an element is equal to that of a small increase in the atomic weight of that element. This law, to which no serious exception is found, is certainly very important to the electronic chemistry of matter.

John Mayow and His Theories. MAX SPETER. (*Chem. Ztg.*, xxxiv, 946.)—This is a history of the views and experiments of John Mayow, who lived from 1645 to 1679, whose theory of respiration and combustion first developed the correct view of the matter, thus forestalling Lavoisier by more than a century. The evidence goes to show that Lavoisier was well acquainted with, and borrowed from, Mayow's work, although he does not refer to him.

Preparation of Titanium. M. A. HUNTER. (*Amer. Chem. Soc. Jour.*, xxxii, 330.)—Pure titanium cannot be obtained by the methods described by Berzelius, or Wöhler and Deville, or by Moissan. A yield of pure Ti, amounting to about 90 per cent. of the theoretical, was obtained by the reduction of titanium tetrachloride with sodium in an air-tight steel cylinder. The metal titanium resembles polished steel. When cold it is hard and brittle, but is very malleable at a low red heat. Its specific gravity is 4.50, and its melting point lies between 1800° C. and 1850° C.

Improved German Silver Alloy. W. R. BARCLAY and J. RODGERS. (*Soc. Chem. Eng. J.*, xxix, 161.)—The addition of a small percentage of cadmium to low-grade German silver, increases the hardness and general working qualities and color to that of a first or second grade alloy containing 22 to 30 per cent. of nickel. An example of modified German silver is copper 57 per cent., nickel 12.5, zinc 28.5, and cadmium 2 per cent.

French Service Powder. G. GEUMANN. (*Zeit. des Schiess- und Sprengstoffw.*, v, 449.)—From 1866 to 1884 considerable alterations were made in the composition and form of black powder and also in the nature of the charcoal used. In 1884 Vieille introduced a smokeless powder, known as "B" powder which with

various modifications is still retained as the service powder. Originally it consisted of insoluble nitrocellulose 68.21 per cent., soluble nitrocellulose 29.79 per cent. and paraffin 2.00 per cent. This was gelatinized with ethyl acetate and made in the flake form. Later this was modified and the composition became insoluble nitrocellulose 29.13 per cent., soluble nitrocellulose 41.31 per cent., $BaNO_3$ 19.00 per cent. KNO_3 8.00 per cent. and Na_2CO_3 2.00 per cent. This was gelatinized first with ether alcohol and later with methyl alcohol. Recently a pure nitrocellulose powder, containing certain stabilizers has been adopted.

Use of Nickel-Steel in Bridge Building. F. BOHNG. (*Chem. Zeit,* xxxiv, 1359.)—Experiments in the use of special steels for bridge construction date back to 1903 in America. In Germany the use of nickel-steel for bridges was first proposed in 1908 and was favorably considered by the authorities. The first work undertaken was a small railway bridge at Oberhausen, of 31.5 metres length between supports. Nickel-steel was also used in the construction of a suspension ferry over the harbor entrance of the Imperial Dockyard at Kiel, and of a covered foot-bridge over the Rhine-Herne Canal near Oberhausen. The steel contained 2 to 2½ per cent. of nickel with a strength of 56—65 kilos per square mm. In some cases nickel may be replaced by the slightly cheaper chromium.

Preliminary Estimate of Production of Portland Cement in 1910.—The production of Portland cement made a new high record in the year 1910. From statistics and estimates received by the United States Geological Survey from about 20 per cent. of the companies manufacturing Portland cement, representing nearly half of the entire output of the country, it is estimated by E. F. Burchard, of the Survey, that the quantity of Portland cement manufactured in the United States in 1910 was between 73,500,000 and 75,000,000 barrels, as compared with 63,508,471 barrels produced in 1909—an increase of 10,000,000 to 12,500,000 barrels, or 15 to 20 per cent. The figures at hand are derived from all parts of the United States, and are therefore considered to be representative of the country at large rather than of any single section or district.

Although the average values for 1910 appear, from returns received thus far, to have been slightly higher than in 1909, prices were far from satisfactory, especially to the large manufacturers in the Lehigh Valley district and in certain of the Eastern States. The year 1911 opens with prices cut 5 to 10 cents a barrel lower than those prevailing in 1910. The construction of several new plants has been pushed during the year, and several plants that were under construction in 1909 became producers in 1910, so that the kiln capacity remains far in advance of the demand.

Commerce of the United States. (*Amer. Mach.*, xxxiii, 714.)—For the first time in the history of our commerce, manufactures now form more than one-half of the total exports. In the 8 months ending with August the figures of the Bureau of Statistics of the Department of Commerce and Labor show that out of a total exportation of 1027 million dollars, manufactures amounted to 542¾ millions or 52.8 per cent. of the whole. Steel and iron are conspicuous in the list of manufactured products which account for the increase.

One Reason Why Steel is Not Uniform. R. E. MARKS. (*Amer. Mach.*, xxxiii, 723.)—He describes somewhat humorously a visit to a steel plant where the heat was determined by the sight-judgment of the "head looker" without any pyrometers or other instruments to determine the temperature. They did not know "what kind of an animal a pyrometer was, but knew there were none round there."

A Laboratory Furnace for Very High Temperatures. D. F. CALHANE. (*Met. and Chem. Eng.*, viii, 581.)—This convenient and inexpensive furnace, of the electrical resistance type, consists of a small, vertical fire-clay muffle, standing within an enclosure formed of four firebricks, the space between the muffle and the bricks is filled with a mixture of Portland cement, magnesium oxide and asbestos. At the bottom of the muffle there is an alundum block on which rests a graphite crucible 2 inches high. The space between the crucible and the muffle is filled with carbon powder, which forms the resistance. A ring of carbon fits flush at the bottom of the muffle and a second ring is provided just above the top of the crucible. The current enters at the bottom, where it is evenly distributed by the ring and leaves at the top ring. To concentrate the heat on the walls of the crucible, an alundum insulating ring is placed at some distance between the graphite rings, practically dividing the mass of resistance carbon into two portions, causing the current to flow along the sides of the crucible. The crucible is lined with alundum to prevent the metals or alloys being contaminated with carbon. The furnace has a capacity of one kilowatt, weighs about 25 lbs., and is capable of heating 60 or 70 Gm. of metal up to 2500° C. The total cost should not exceed $5.00.

The Sun as a Source of Heat in Chemical Experiments. A. STOCK and H. HEYNEMANN. (*Ber. Deutsch. Chem. Gesell.*, xlii, 2863.)—If the substance to be treated is contained in an exhausted glass vessel, the heat can be concentrated on the substance itself, so that a very refractory container is not requisite. The apparatus employed is a plano-convex lens of 40 cm. diam. and 50 cm. focal length used to concentrate the sun's rays on

the substance, which was placed in a magnesia crucible. Pieces of copper and cast-iron were melted almost instantly, while crystallized silicon, M. Pt. 1450° C., was melted in a few seconds. A thermo-junction supported at the centre of the flask gave a reading of 1030° C. in vacuo; but only 675° C. when unexhausted.

Removal of Tin from Tin-plate. ANON. (*Brass World*, vi, 434.)—It is well known that a strong solution of sodium hydroxide (caustic soda) will dissolve metallic tin from tin-plate scrap, leaving the bare iron. The solution contains the tin as sodium stannate from which it can be recovered electrolytically. The difficulty in this process is that after a while the soda solution will not attack the tin. Heinrich Brandenburg overcomes this by constantly removing a portion of the solution by a pump and supplying fresh caustic soda in its place. It is stated that the solution will then attack the tin regularly and thus the difficulty is overcome and the process made continuous.

The Influence of Pure Science in Engineering. SIR J. J. THOMSON, F.R.S. (*Eng. Record*, lxii, 679.)—This is a Presidential address read before the Junior Institution of Engineers, and is worthy of perusal by engineers and by scientists. It shows that "the distinction between pure science and engineering is one, not of method, but of aim." Its perusal is strongly recommended.

The Heroult Patents. ANON. (*Iron Age*, lxxxvi, 1110.)—The United States Steel Corporation has acquired the rights for the United States in the Heroult process for electric steel making and refining. Two fifteen-ton Heroult furnaces have been operated for a year, one at the South Chicago works of the Illinois Steel Co., and the other at the South Works, Worcester, Mass., of the American Steel and Wire Co. At South Chicago several thousand tons of rails and a large tonnage of axles have been made of electric steel, the Heroult furnace operating as an adjunct of the Bessemer converter. At Worcester the Heroult furnace is used to refine open-hearth steel, an exceptionally high quality of steel being made from ordinary materials.

The Volatile Constituents of Coal. M. J. BURGESS and R. V. WHEELER. (*Proc. Chem. Soc.*, xxvi, 210.)—With all coals, whether bituminous, semi-bituminous or anthracite, there is a well defined decomposition point at a temperature between 700° C. and 800° C., which corresponds with a marked increase in the quantity of hydrogen evolved. With bituminous coals this increase of hydrogen evolved falls off at temperatures above 900° C., but with anthracite coal the evolution is maintained up to 1100° C. It is further shown that ethane, propane, butane, and probably higher members of the

paraffin series of hydrocarbons form a large percentage of the gases evolved at low temperatures, but that at above 700° C. the evolution of such hydrocarbons practically ceases. The idea is advanced that coal, of whatever geological age, contains a compound which decomposes at temperatures above 700° C. under atmospheric pressure, and yields hydrogen as its chief gaseous product. It seems probable that the same compound is responsible for the hydrocarbons of the paraffin series that make their appearance at low temperatures.

Preparation of Metallic Vanadium. W. PRANDTL and B. BLEYER. (*Ber.*, xliii, 2602.)—Vanadium pentoxide can be reduced by the thermite reaction by mixtures either of aluminum and calcium or aluminum and fluorspar in magnesia crucibles, and by aluminum alone on a fluorspar hearth. Whichever method is used, however, the resulting vanadium regulus never contains more than 95 per cent. of vanadium. The deficit does not consist of impurities introduced by the calcium, but is practically all oxygen, as only traces of aluminum, silicon, and iron could be detected. Probably a lower oxide of vanadium and metallic vanadium unite to form an alloy which withstands further reduction.

Axin, a Mexican Lac. H. BOCQUILLON. (*J. Pharm. Chim.*, ii, 406.)—Axin is a waxy secretion of a Mexican rhyncotrous insect. When fresh it has the consistency of butter, a yellow color and an odor of rancid fat. It melts at 38° C. and is soluble in hot alcohol and in ether. When exposed to the air it rapidly absorbs oxygen and becomes dark brown, hard and insoluble in the above solvents. It is readily saponified. Hoeffer has extracted from it a definite substance "axinin," which yields axinic acid and glycerol. In its properties of darkening and hardening on exposure to air, axin closely resembles Japan lac. It forms an excellent lacquer for wood and metals, and is used by the natives as a varnish for pottery.

Petroleum in the Argentine. W. MECKLENBURG. (*Chem. Zeit.*, xxxiv, 1150.)—Petroleum has as yet only been found in the Argentine in the provinces to the east of the Andes, notably at Jujug, Salta, Mendoza, Los Buitres, Neuguén, and Chubut, but it probably occurs in many other places. Argentine oils are viscous and of dark color, that from Chubut being quite black. The Yacuiva oils have the best appearance and those of Salta come next. They are reddish brown and have a strong greenish fluorescence. The oils of Salta, Jujug, and San Rafael (Mendoza) have an odor of lamp oil, while the oils of Cacheuta and Comodoro Rivadavia, from the deep strata, have an odor of benzine. The Argentine petroleums resemble Baka oils much more closely than Pennsylvania oils.

Polychrome Screens for Color Photography. L. GIMPEL. (*French Pat.*, 414,953, 1909.)—A screen composed of parallel lines is photographed on an ordinary photographic plate, and the developed and fixed image is toned in a primary color (*e.g.*, red) to give an image of as fine a grain and as transparent as possible. The film is now coated with a sensitive emulsion, and the screen is photographed again on this, but with the lines perpendicular to those of the first image; after development and fixing, the second image is toned in a second primary color (*e.g.*, blue) and the plate is again coated with emulsion, and exposed to the light through the crossed screen already formed, so that only the portions not colored are affected; it is finally developed, fixed, and the image of small squares toned to the third primary color (yellow).

Metallic Titanium. L. WEISS and H. KAISER. (*Zeit. Anorg., Chem.*, lxi, 345.)—The paper describes the methods of preparation and analysis of amorphous and cast titanium and of titanium "aluminides." A product prepared by fusing the amorphous metal contained 97.41 per cent. titanium and its specific gravity was 5.174 at 19° to 20° C., mean specific heat 0.1418 and heat of combustion 24.4 calories per equivalent. It melts at 2200° to 2400° C.

Preventable Blast-Furnace Accidents. R. H. SWEETSER. (*Iron Age*, lxxxvi, 1022.)—A valuable and useful paper on the prevention of such accidents. Mr. Sweetser points out that accidents can arise from slips and from the different kinds of furnace gas, *e.g.*, the normal gas and the blowing in gas, from explosions in the cold blast pipe, from slips, break outs, and blowing outs. This paper will doubtless be very interesting to blast-furnace men.

Effect of Heat on Cast-Iron. (*Amer. Mach.*, xxxiii, 720.)—Heating cast-iron to a dull red heat and allowing it to cool, repeated 30 or 40 times, makes it porous. Cast-iron plates so treated, after being planed down to a ¼-inch thickness, will absorb a few drops of oil placed on the top, which will pass through the iron to the lower side of the plate in less than 5 minutes.

Specification for the Manufacture and Testing of Retort Material. (*Jour. of Soc. Chem. Ind.*, xxx, 28.)—A joint subcommittee formed of five representatives elected by the Retort and five of the Refractory Materials Committee of the Institution of Gas Engineers, with the assistance of J. W. Mellor, of the Staffordshire County Pottery Laboratory, has drawn up a specification for this purpose. The leading points covered are: Constituents, Chemical Analysis, Refractoriness, Surfaces and Texture, Contraction, Inspection and Testing. To those interested this will be found a valuable paper.

Brass-Melting Furnaces. W. M. CORSE. (*Iron Age,* lxxxvii, 82.)—The new types of brass furnaces introduced during the last 10 years have led to a thorough investigation of the causes of brass founders' troubles. It was a revelation to many that zinc could be volatilized to the extent of 45 per cent. during the process of melting. These furnaces may be divided into five classes.

1. Stationary crucible furnaces, coke or coal fired, using natural or forced draft.
2. Stationary crucible furnaces, oil fired.
3. Tilting crucible coke furnaces.
4. Tilting crucible oil furnaces.
5. Tilting open-flame oil furnaces, without crucibles.

The quality of the metal from class 1, with natural draft is excellent, provided the draft equals 2″ or 3″ water suction. Poor draught causes inefficient working.

In class 2, the quality of the metal depends on the design of the furnace and on the air pressure. Generally the lower the air pressure, the better the metal.

In class 3, the melt is much faster, with the disadvantage of double pouring.

In class 4, there is the same efficiency as in class 2, with the double pouring factor.

In class 5, there is the same efficiency as in the other oil furnaces, also with the double pouring factor.

Pilbarite from the Pilbara Goldfields. E. SIMPSON. (*Chem. News,* cii, 283.)—Pilbarite is a canary yellow, brittle, earthy, amorphous mineral of 2.5 to 3 hardness, and has a specific gravity of 4.4 to 4.7. It is found in small quantities at Wodgina, Pilbara Goldfields. The mineral is essentially a hydrated silicate of lead, uranium and thorium. It is readily decomposed by mineral acids and is strongly radio-active.

Direct Reduction of Iron Ores in the Electric Furnace. M. G. ARNOU. (*Rev. de Metall.,* vii, 1190.)—Hæmetite, magnetite, and clay-ironstone were reduced with either wood charcoal, coke, or anthracite in an electric furnace capable of producing 15 tons of metal. Finely powdered mineral was reduced as easily as an agglomerate of briquettes. The analysis of seven consecutive castings closely approximate to 0.08 per cent. carbon, 0.10 manganese, 0.02 silicon, 0.02 sulphur, with traces of phosphorus. It is stated that the metal, so far as tested, shows a perfect similarity to Swedish iron.

New Compounds of Nitrogen and Hydrogen with Lithium. F. W. DAFERT AND R. MIKLAUZ. (*Monats Chem.,* xxi, 981.)—At the ordinary temperature metallic lithium in a current of pure dry nitrogen is gradually but completely converted into lithium

nitride, Li_3N. At 400° C. the reaction is very rapid, but as the substance attacks the container the final product is very impure. The nitride heated to 220°–250° C. in a stream of hydrogen absorbs the gas forming tri-lithium ammonium, Li_3NH_4. This when heated to 340° C. loses hydrogen, and reabsorbs it on cooling, but when heated to 480° C. the loss of gas is permanent, and tri-lithium amide, Li_3NH_2, is formed. Heated to 600°–800° C. in a steam of hydrogen it forms lithium hydride. All of these compounds are decomposed by water with evolution of ammonia.

The Oxides Which Color the Oriental Sapphire. A. VERNEUIL. (*Comptes rend.*, cli, 1053.)—Titanium has not been hitherto detected in the clear sapphire, and its color is due to iron oxide. The identity of the color of the synthetic product with that of the natural stone indicates that titanic acid or oxide produces the coloration. The analysis of Australian, Burmese and Montana sapphires shows they contain iron oxide, and a titanium oxide equivalent to 0.031–0.058 per cent. of titanic acid. The conclusion is drawn that the Oriental sapphire owes its fine blue color to iron oxide and titanium oxide.

Reaction in the Electric Arc. PAUL SABATIER. (*Comptes rendus*, cli, 1328.)—M. Salmon has described an arrangement "for passing the electric spark between two electrodes each pierced by an axial channel, so that gas passes through one channel and the products of the reaction escape by the other one." One result obtained in this way was the combination of carbon and nitrogen to form cyanogen.

For ten years I have used a very simple analogous arrangement, consisting of two hollow carbons. They only differ from M. Salmon's arrangement in that the quartz tube envelope is replaced by a cylindrical glass lamp-chimney protected on the interior from the radiation of the arc by a fine metallic lining. In this apparatus the synthesis of acetylene in a current of hydrogen, and of ammonium cyanide in ammonia gas, can be effected. But it should be noted that, with a current of 90 volts and 15 amperes, absolutely dry nitrogen gives no appreciable cyanogen, while hydrocyanic acid is plainly formed when the nitrogen is a little damp, or mixed with hydrogen or a hydrocarbon.

The Carborundum File. ANON. (*Eng. Mag.*, xl, 3.)—Carborundum is the hardest and sharpest of all abrasive materials. Each grain is as hard and as sharp as a diamond, and cuts fast and clean, does not wear smooth nor does the file fill or glaze. The carborundum file will remove material that the steel file cannot touch. One such file it is stated, will outlast twenty steel files, and will cut metals which a steel file cannot touch.

The Outerbridge Silicon Alloys. (*Iron Age,* lxxxvii, 44.)—This alloy patened by Mr. A. E. Outerbridge of Philadelphia makes gray-iron castings stronger, cleaner and more homogeneous; it reduces shrinkage, cracking and blow holes and increases ductility. It controls the character of the iron drawn from the cupola as a governor controls the revolution of an engine, and enables the grade of iron in individual ladles to be varied to suit special castings. It drives the dirt and slag to the top where it can be skimmed off. No expert or chemist is required to direct its use, as it is only necessary to drop a small quantity of the finely ground alloy on the bottom of the ladle before tapping.

Energy from Niagara. (*Eng. and Mining Jour.,* xc, 1119.)—The *Electrical World* states that the energy from Niagara Falls, including operation on both sides of the Falls, is used at the rate of 126,000 h. p. for electro-chemical process; 56,200 h. p. for railway service; 36,400 h. p. for lighting, and 54,540 h. p. for various industrial services; the total being 273,140 h. p. Since the water of Niagara Falls represents probably 5,000,000 h. p. it would seem that only about 5.5 per cent. of the available power is being utilized at present.

Low Temperatures in the Leather Industry. W. EITNER. *Zeit. Angew. Chem.,* xxiii, 2268.)—Although temperatures below zero are harmful, the cooling of hides before preservation with salt and storage of the salted hides at temperatures below 10° C. is advantageous. Unhairing by the sweating process is also best regulated by means of artificial cooling.

Matches in China. (*La Mercure Scientifique,* lxxiv, 4.)—The Japanese have developed the extensive manufacture of matches in China. There are factories at Tientsin, Pekin, Hangkow, Shanghai, and other places. The viceroys do not allow the erection of several factories in the same town, so that each factory has a kind of local monopoly. The factory at Hangkow employs 3600 hands, and produces 50 or 60 tons daily. If this development increases the Japanese manufacturers will be unable to stand the competition.

The Efflorescence of Bricks. JULES GARÇON. (*Bull. Soc. D'Encour.,* cxiv, 455.)—The color of the efflorescence of bricks is generally white, but sometimes yellow or green, and is usually seen on red bricks. In time it spreads over a whole building and gives it a dusty appearance. It is formed when the brick contains soluble salts, generally sulphates; but sometimes chlorides. When the bricks absorb water it evaporates on the surface leaving the salts. These soluble salts may have been in the clay, in the water used to wet the clay or in the mortar. Sometimes these salts are

formed in firing the brick by the sulphur dioxide gas from sulphurous coal. To avoid this, if the clay contains the salts it should be well washed, or be left exposed to the rain for 6 months or a year. If the clay contains pyrites, 4½ pounds of barium chloride or 22 pounds of barium carbonate should be added to the water for each ton of clay.

The Influence of the Magnetic Field on Spectral Rays. G. A. HEMSALECH. (*Moniteur Scientifique*, lxxiv, 57.)—The influence of the magnetic field on the duration of the spectral rays emitted by luminous vapors in the electric spark is that the duration of almost all the rays of iron is diminished and the intensity of the action upon the different rays is selective. Almost all rays decrease in intensity, except in the immediate vicinity of the electrode, where they are all reinforced by secondary reactions. (1) *The general effect*, which is independent of the orientation of the discharge with respect to the lines of force of the magnetic field, results in the decrease of the duration as well as of the luminous intensity of the rays emitted by the metallic vapor. (2) *The longitudinal effect* produces a prolongation of the duration of the metallic rays and an increase of their brightness as well as of the brightness of the air. This action is only apparent when the spark flashes parallel to the lines of force. (3) *The transverse effect* is only obtained with very slow discharges (self-induction in the discharge circuit of the condenser) when the spark flashes perpendicularly to the lines of force. This effect is shown by a prolongation of the duration of certain rays, and is due to the displacement experienced by the oscillation which carries the current of the discharge under the influence of the field. Its action is selective.

Nickel Anodes. ANON. (*Brass World*, vi, 433.)—Nickel anodes that have been sand-blasted work better than those left as they come from the sand mold.

Electro-deposited Nickel. ANON. (*Brass World*, vi, 437.)—By heating electro-deposited nickel that is hard and brittle in an atmosphere of hydrogen to a red heat, it becomes soft and ductile.

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